BLM LIBRARY
88015195

PB 196 171

PUBLIC LAND POLICY AND THE ENVIRONMENT: PART III ENVIRONMENTAL QUALITY AND THE PUBLIC LANDS; A GENERAL SYSTEM FOR ENVIRONMENTAL RESOURCE ANALYSIS

Landscapes, Inc.
Madison, Wisconsin

Revised December 1970

SURPLUS
to
Library Needs

NATIONAL TECHNICAL INFORMATION SERVICE

Distributed ... 'to foster, serve and promote the nation's economic development and technological advancement.'

U.S. DEPARTMENT OF COMMERCE

This document has been approved for public release and sale.

LIBRARY
Bureau of
Denver,

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

KF
5602
.P976
v.4
c.1

OF THE INTERIOR
ND MANAGEMENT
ER'S CARD
y and the environment.
OFFICE
DATE RETURNED
n 1279-3 (May 1982) (formerly DSC 1279-3a)

2422267
ID 88015195

Vol. 4

HD
216
.P824
1970
v. 4

PB196171

PUBLIC LAND POLICY AND THE ENVIRONMENT

Part III

Environmental Quality and the Public Lands; A General System for Environmental Resource Analysis

A Study Prepared for the
Public Land Law Review Commission

by

Landscapes, Inc.
Madison, Wisconsin

Steinitz Rogers Associates, Inc.
Cambridge, Massachusetts

COLOR ILLUSTRATIONS REPRODUCED IN BLACK AND WHITE

Republished with revisions December 1970

Details of illustrations in
this document may be better
studied on microfiche

Prepared under contract with the Public Land Law Review Commission. The opinions, findings, conclusions and data expressed in this publication are not necessarily those of the Public Land Law Review Commission. This publication constitutes only one of a number of sources of information utilized by the Commission in the conduct of its public land study program.

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

BUREAU OF LAND MANAGEMENT LIBRARY
Denver, Colorado
88015195

STANDARD TITLE PAGE FOR TECHNICAL REPORTS

1. Report No. PLLRC-29-4

2. No.

4. Title and Subtitle Vol. 4: PUBLIC LAND POLICY AND THE ENVIRONMENT. Part III: Environmental Quality and the Public Lands; A General System for Environmental Resource Analysis; Part IV: Policy Issues and Alternatives

5. Report Date 12/1/70

6. Performing Organization Code

7. Author(s) Landscapes, Inc., Madison, Wisc.; Steinitz Rogers Assoc., Cambridge, Mass.; Hansen, Heyman & Twiss

8. Performing Organization Rept. No. 29

9. Performing Organization Name and Address

Public Land Law Review Commission
1730 K St., N. W.
Washington, D. C. 20006

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Agency Name and Address

same as 9 above

13. Type of Report & Period Covered interim

14. Sponsoring Agency Code

15. Supplementary Notes

Volume [illegible] [illegible] with

16. Abstracts

Part III of the study makes it clear that the environmental effects of land use cover a complex of biological and physical relationships, such as impacts on air and water quality, as well as those affecting aesthetic, cultural and historical values. It describes two methods of data collection and analysis that may be used to discern likely environmental impacts of proposed land uses and management practices prior to undertaking such actions.

Part ~~IV~~ describes how the three previous parts of the study each relate to the overall study, ~~and~~ contains an analysis of problems identified and possible alternatives to existing environmental policies applicable to the public lands.

17. Key Words and Document Analysis. 17a. Descriptors

environment quality, public lands, policy issues, resource analysis

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Distribution Statement

available through N.T.I.S.

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages

22. Price

Public Land Law Review Commission

PUBLIC LAND POLICY AND THE ENVIRONMENT. Volume 4:

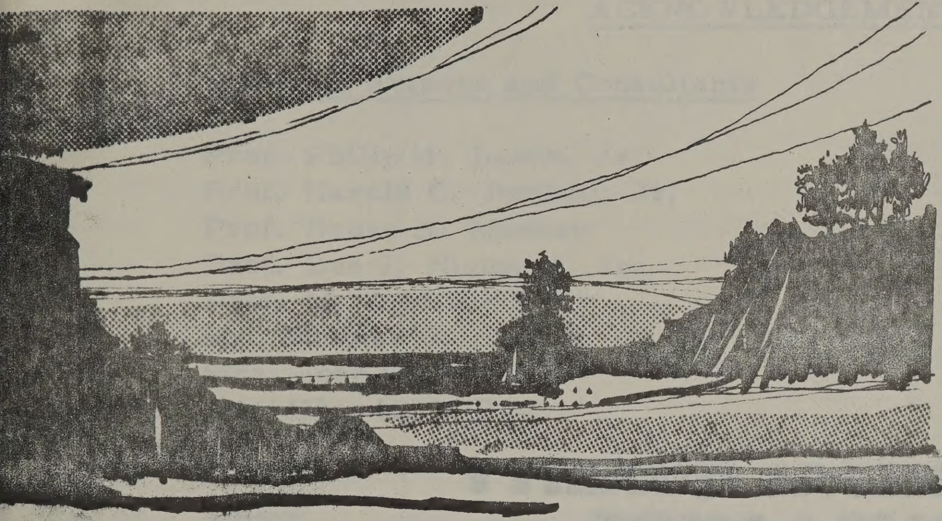
Parts III: Environmental Quality and the Public Lands; A General System for Environmental Resource Analysis;

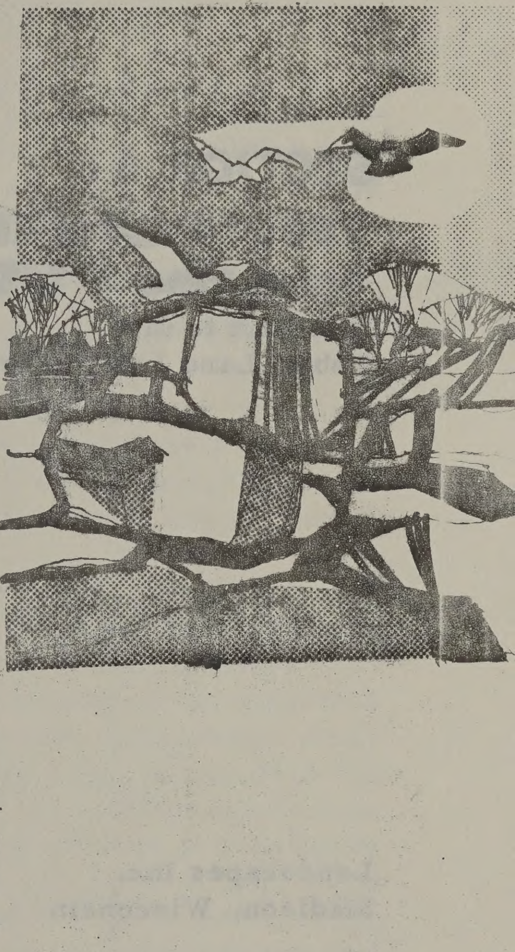
and IV: Policy Issues and Alternatives

Landscapes, Inc., Madison, Wisconsin
Steinitz Rogers Associates, Inc., Cambridge, Massachusetts
Roger P. Hansen, Ira Michael Heyman, Robert H. Twiss

Republished with revisions December 1970

TEXT OF COVER PRINT
(PLS DONT
THIS PAGE)





Section A Environmental Quality and the Public Lands

Section B A General System for Environmental Resource Analysis

SECTION A:

ENVIRONMENTAL QUALITY and the PUBLIC LANDS

A Report to the
Public Land Law Review Commission

Landscapes Inc.
Madison, Wisconsin

ACKNOWLEDGEMENTS

Principal Authors and Consultants

Prof. Philip H. Lewis, Jr.
Prof. Harold C. Jordahl, Jr.
Prof. Bruce H. Murray
Prof. Ben J. Niemann, Jr.
Prof. M. Atef Sharkawy
Mr. Thomas F. Slater
Mrs. Joan Gefke
Mr. Allen H. Miller

Editor

David W. Stewart

Graphics

Prof. Bruce H. Murray
Mr. Robert R. Hartman
Mr. James Johnson
Mr. James A. Wright
Mrs. Inas Fahmy
Prof. M. Atef Sharkawy
Mr. John O. Hoosen
Mr. Charles Holzbog
Mr. Robert J. Slater

Typists

Mrs. Judy Schmidt
Mrs. Joan Gefke
Miss Rebecca A. Gonzalez
Miss Joyce Olson
Mrs. Mary Hamacher

Credits

Certain illustrative materials taken from Appendix B, "Aesthetic and Cultural Values," Upper Mississippi River Basin Comprehensive Study, prepared by Landscapes, Inc. under the auspices of the U.S. Department of Interior, National Park Service, Northeast Region.

FOREWORD

The prime objective of our two reports is the improvement of decision making in agencies with responsibilities for public land so that the resource qualities of these public lands can be maintained and enhanced. The studies present descriptions of methods for the identification of these significant environmental resources and qualities and the determination of the impacts of their use. Two approaches to environmental analysis are presented, each of which can be supportive of the other.

Environmental Quality and The Public Lands presents the approach developed by Landscapes Inc. These methods are essentially holistic, seeking patterns of landform which should influence the quantities and qualities of resource use which can be applied to land, and in particular public lands. The approach describes the requirements of an inventory and analysis system for bringing together contributions of the behavioral, natural, and physical sciences with "form determinants" from the engineering and planning design fields. The methods emphasize the use of existing personnel and administrative structures as well as the analysis of known information. Techniques for education -- environmental awareness -- are seen as a fundamental requirement for increasing the awareness in both the general public and the responsible agencies, of the value of these environmental resource qualities. Examples of the application of these methods are included.

In A General System for Environmental Resource Analysis the Steinitz Rogers group presents the methods which they have developed for comprehensive environmental resource inventories and analyses, with particular emphasis on the analysis of impacts of land use on environmental resources. Their approach is directed first towards increasing the understanding of how the various environmental systems function, second, to increasing the ability of decision makers to predict their interrelationships, and third, to improving the ability to control them. The methods emphasize the identification of basic data categories, and, through various computer-using methods, the aggregation of these into analyses which can demonstrate the constraints and opportunities of development decisions. They stress precision and validity of data, and the specification of measures of land capability. Examples of applications of the methods described are presented.

The two approaches alone do not relate exclusively to public lands. However, there are specific characteristics in the implementation of methods and policies of land and resource use which distinguish the public lands. Issues related to the planning processes of decision making and implementation are found in Environmental Quality and the Public Lands, while those concerning the management organization for the collection and control of resource information and analysis are found in A General System for Environmental Resource Analysis.

These reports present opportunities for improved decision making, and their application to the public lands are seen as critical to the establishment of a public environment of high quality.

Philip H. Lewis, Jr.
Madison, Wisconsin

Carl Steinitz
Cambridge, Massachusetts

January, 1970

TABLE OF CONTENTS

Section A.

Chapter Page

I. INTRODUCTION 1

A. Public Land Use Objectives 1
B. Federal Land Acquisition Policies 4
C. Environmental Quality: A Definition 4
D. Environmental Quality Measurement 6
E. Impacts of Man Affect Environmental Quality 7

II. IMPACTS ON PUBLIC LANDS 9

A. Economic versus Environmental Land Use Planning 10
B. Projections of Future Use Impacts 13
C. National Impacts of Economic and Population Expansion 14
D. Land Use Changes on Public Lands 16
E. Specific Types of Impacts on Public Lands Resources 17
F. Chart of Principal Human Resource-Use Impacts on Publicly Owned Lands 18
G. Extractive Resource Utilization 27
H. Surface (Spatial) Land Uses 31
I. Other Resource Development Uses 34
J. Service (Non-Consumptive) Land Uses 36
K. Administrative Managerial Operations 37
L. The Decision-Making Process: An Analysis and Evaluation 37

III. AREAS OF URBANIZATION IMPACT 39

A. The Urbanite in His Environment 40
B. The Urbanite Escapes to the Natural Environment 45
C. What People Seek in Their Environments 48
D. Intrinsic and Extrinsic Values 54
E. Creating Balanced Development 58

Chapter Page

IV. ENVIRONMENTAL QUALITY 62

A. Man Becomes Aware of His Environment 63
B. Environmental Options 64
C. Resource Inventory Techniques 65
D. Basic Environmental Ingredients 66
E. Environmental Diversity 70

V. RESOURCE PATTERN RECOGNITION 73

A. Form Determinants 74
B. Patterns That Directly Threaten Human Life and Investment 75
C. Patterns That Offer Hope for Survival 82
D. Patterns That Offer Hope for Human Well-Being and Happiness 90
E. Recreation Resource Symbols Used in Wisconsin 111

VI. STEP-BY-STEP DEMONSTRATION OF FIRST APPROXIMATION INVENTORY 118

A. Resource Values Identified 118
B. Symbols Selected 121
C. Base Maps for Plotting Selected 123
D. Upper Mississippi River Basin Study Map 128
E. Six Month Organizational Chart Drafted 129

VII. DESIGN CHARACTERISTICS OF FORM DETERMINANTS 131

A. Areal and Corridor Forms 131
B. Designing Facilities and Land Uses Adjacent to Areal and Corridor Patterns 134

VIII. PLANNING AND DESIGN TEAMS AND LABORATORIES 138

A. Design Guidelines 138
B. Public Lands as Model Demonstration Areas 139
C. Regional Laboratories 140
D. Environmental Awareness Education 141

Chapter (Chapter VIII - continued) Page

E. Needed: A National Environmental Plan 142
F. Indiana Dunes Pilot Project 143
G. Needed: A System of Environmental Awareness Centers 150

IX. ENVIRONMENTAL PLANNING AND THE FEDERAL INSTITUTION 158

A. Planning 158
B. Characteristics Which Distinguish Public Land Planning 162
C. Agency Structure and Planning Influences 164
D. Planning in Land Management Agencies 169
E. Applying Environmental Quality Dimensions in Planning 174
F. Organizational Structure 181
G. Plan Implementation 189
H. Councils and Public Participation 191
I. An Environmental Quality Policy for the Public Lands 193

APPENDICES 197

A. Goals of the English Conference Entitled "The Countryside in 1970" (Prince Philip's Second Conference)

B. Toward an Interdisciplinary Approach; Rationalization in Environmental Design

C. Rationale for a Structured Technique of Quantitative and Qualitative Determination of Visual Landscape Quality

D. A Computer Approach to the Alignment of the Milwaukee-Green Bay Interstate

E. An Environmental First Approximation Study of the State of Alaska (Five Maps)

Chapter I

INTRODUCTION

The Federal public lands of the United States fall into two major categories: (1) the residual public domain administered by the Bureau of Land Management consisting of 437 million acres (175 million in 11 Western States and the balance in Alaska), and (2) lands withdrawn from the public domain or acquired by Federal agencies -- both for specific national objectives. This latter group includes 255 million acres of withdrawn land and 54 million acres of lands acquired from non-federal owners.

The largest single Federal land-holding agency under this second category is the Forest Service (U. S. D. A.) with 186 million acres. The National Park Service (U. S. D. I.) administers 23 million acres and the Bureau of Sports Fisheries and Wildlife, 26 million acres. The remaining large acreages are under the Defense Department, Bureau of Reclamation and Atomic Energy Commission administration with a scattering among smaller agencies.

While more than 90% of the Federally owned lands lie West of the Great Plains, those located in the Middle Western and Eastern states (largely acquired) are of critical importance for wildlife, watershed, recreation or timber values.

PUBLIC LAND USE OBJECTIVES

Because agency land use objectives vary widely in purpose and the lands contain diverse environmental qualities, the impacts from human usage take many directions and effects. A National Park, dedicated by law to preservation of scenic quality and recreational uses, will not ordinarily be directly affected by the logging, grazing or mineral exploration impacts to which National Forests or public domain lands under multiple use management are subjected. Military and A. E. C. lands are of value to their agencies for their spatial characteristics rather than resource values.

Public lands run the spectrum of deserts, mountains, prairie grasslands, high plains, forests and wetlands. They combine minerals, forage, timber, and wildlife resources. But throughout all of these lands the environmental values necessary to sustenance of life on the Planet Earth include water from their watersheds, oxygen produced from chlorophyl to enrich the atmosphere, scenic qualities of varying kinds and physical resources of economic worth. Until quite recently, these environmental and aesthetic characteristics have been little considered in planning and decision-making -- in part because no systematic method to measure and record them has been available.

In capsule form, the following table sets forth the allocation of the original 1.8 billion acres of public domain land.

ALLOCATION OF ORIGINAL PUBLIC DOMAIN(1)

I. Transfers out of Federal Ownership	Million Acres	Purpose
Grants to States	229	Swamp, School, R.R.'s, etc.
Private Sales and Grants		
Homestead Acts	287	(Agriculture)
R.R. Grants	94	(R.R. construction)
Miscellaneous Grants and Sales	128	(Special lands)
Other Private Disposition	302	(Includes frauds, mining claims, etc.)
TOTAL	811	
II. Withdrawals for Specific Federal Purposes		
National Parks	18	Preservation of scenic values and recreation
National Wildlife Refuges	23	Wildlife conservation
National Forests	160	Multiple use of all natural resources
Bureau of Reclamation	7	Irrigation projects
Indian Lands	7	Indian homelands
All other - Military, A.E.C., etc.	40	National defense, nuclear testing, etc.
TOTAL	255(2)	
III. Residual Public Domain Under Bureau of Land Management		
11 Western States	174	
Alaska	263	
TOTAL	437	

Table I.1

---

(1) Derived from Public Land Statistics--1968

(2) In addition to these public domain withdrawals, 54 million acres of non-federal lands have been acquired by purchase or exchange to the above as follows: National Parks--4.7 million acres; National Forests--26.2 million acres; Fish & Wildlife Service--3.3 million acres; Bureau of Reclamation--1.7 acres; Indians--7 million acres; all other--18 million acres.

Published maps of public lands in the United States (such as that in Fig. I.1 below) traditionally show the location of large Federal land holdings by delineated boundaries, map colors, and designated names (National Forests, National Wildlife Refuges, etc.) except for the residual public domain which is not so clearly defined (See map of public lands - U.S.G.S. - B.L.M., 1965). In addition, topography, vegetative cover, soils, drainage patterns, wildlife ranges, geological formations, cultural changes, institutional systems and economic data, along with a variety of other social and natural phenomena, have been mapped and described. Accurate maps containing inventory data of most of these physical and institutional factors are available for many parts of the public lands.

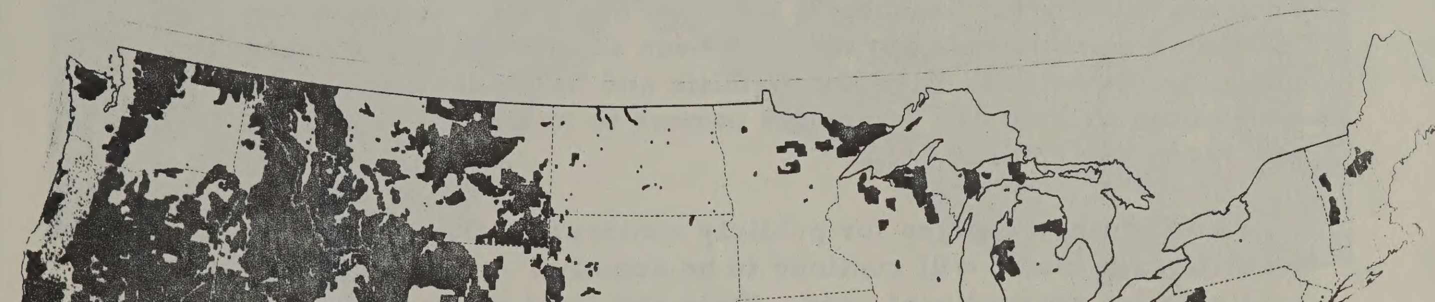


Fig. I.1

FEDERAL LAND ACQUISITION POLICIES

Although for most of the period since the public lands were acquired by treaty or purchase, disposal was a major objective until 1900, a major reversal has been taking place in the Twentieth Century. With the advent of the Conservation Movement at the turn of the century, a policy of retaining some public domain lands and acquiring certain key private lands has been actively pursued by the Congress with full public support. Passage of the Weeks Law in 1911 signalled the beginning of this reversal in the historic trend of land disposal.

Public realization of the need for watershed protection, recreational areas to serve increasing population, protection of wildlife and preservation of areas of particularly scenic value led to this change in both state and national land policy. It can therefor be said that environmental protection has been a concern of the American people for several generations insofar as public protection over key tracts is concerned.

During the 1960's, acquisition of lands for public purposes was accelerated with the passage of the Land and Water Conservation Fund. Already a considerable acreage has been authorized by Congress for purchase by the U.S. Fish and Wildlife and National Park Services. Substantial in-holdings by private owners in National Forests and parks are yet to be acquired.

Substantial acreages for publicly constructed flood control and other types of reservoirs will continue to be acquired -- much of which will be available for recreational uses. State and local governments have plans for acquiring more prime areas for scenic, recreational, open space and related environmental values. As a tool of safeguarding environmental quality, land acquisition has become strongly supported public policy for accomplishing this objective.

ENVIRONMENTAL QUALITY: A DEFINITION

What are the ingredients of the "environmental quality" that is to be preserved or enhanced on the public lands? In deriving a definition for this loosely used phrase, it would be well to start with the individual words themselves. From Webster's New World Dictionary:

- "environment - a surrounding or being surrounded; something that surrounds; surroundings; all the conditions, circumstances, and influences surrounding and affecting development of, an organism or group of organisms.

- "quality - the degree of excellence which a thing possesses; hence, excellence, superiority."

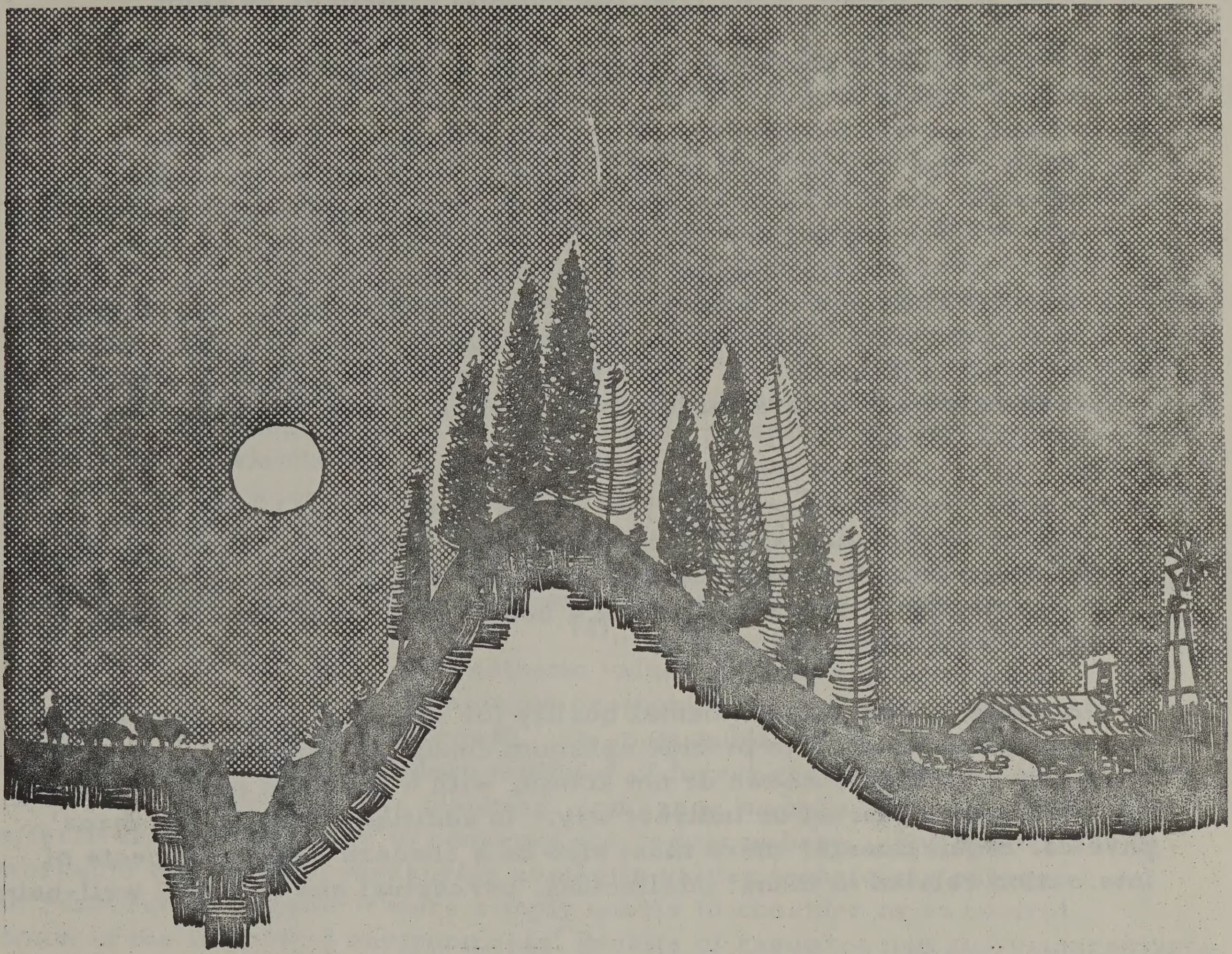


Fig. I. 2

In talking about surroundings it is essential to identify who or what is being surrounded. An individual "organism", such as a deer, a butterfly, an oak tree, etc. or a man can be specifically isolated; so can collective groups such as animals, insects, plants or human beings. For the purposes of this report, all of man and nature, all living things upon the earth are considered as being surrounded by an environment.

The concept of quality is both subjectively abstract and finitely objective. Quality in terms of aesthetic values is often largely a judgement issue and very dependent upon perceptual conditioning. On the other hand, quality in terms of life sustaining elements can be identified by often very precise measurements.

One ecologist has suggested that environmental quality can be defined in terms of the health of the total life support system as he said:

> "A beautiful environment is one that is functioning properly; where energy from sunlight, water, minerals, and soil are channeled into the production of wood and grass, and wildlife, farm crops or garden flowers; where cities provide the challenge of work, the pleasures of play, and the security of homes; and where their populations are not cut off from those natural scenes that can recreate, inspire, and sustain them. Malfunction, whether reflected in congested traffic and polluted air, water that is fit for neither drinking nor swimming, decaying neighborhoods, or eroding hillsides, is ugliness; it reflects a breakdown in both man-made and natural order and a decline in both human and environmental health.
>
> "Ecologists suggest that just as the stability and health of a natural community are dependent upon its diversity, the interactions among many kinds of plants and animals, and adequate space for each member, so the welfare of a human community may depend on equivalent interrelationships."(3)

A concern with environmental quality for man then implies a related concern with a balance to privide optimum conditions for the survival of all living organisms, known or not known, with which man might favorably interact in some direct or indirect way. In addition to caring for mans' physical requirements, there must also be a concern with the aspects of interaction related to mans' intellectual, perceptual and spiritual well-being.

ENVIRONMENTAL QUALITY MEASUREMENT

In entering the era of more intensive uses of public lands, it is appropriate that an appraisal of the methodology for planning their development and use be carefully analyzed. Policies for obtaining additional public lands should also be thoroughly reviewed.

Since the environmental and aesthetic resources of these lands have not as yet been inventoried on a wide scale, it is not possible to set them forth in quantitative terms or provide specific lists of proportionate qualitative values. It is the objective of this study to provide these concepts as a basis for guiding human impacts so as to minimize deleterious effects and to harmonize such impacts with existing cultural and natural qualities. A first step, of course, is the measurement of the environmental and landscape resources as a new dimension of resource inventorying.

---

(3) From Sea to Shining Sea, page 120, the President's Council on Recreation and Natural Beauty, Washington, D.C., 1968.

The new concept of environmental quality measurement has arisen as a result of man's concern over the effects of his works on our limited landscape and environmental resources. For 350 years the thrust to conquer the wilderness and subject it to man's material will has dominated the American social system. Except in Alaska and limited areas in western states, true wilderness is about gone. There is no frontier. Hills, mountains and waterways have been irreparably scarred by mineral extraction; powerlines, pipelines, and highways have been routed in straight lines without regard to scenic vistas or soil eroding effects. Swamps and lowlands have been drained without concern for wildlife, water conservation or accelerated downstream flooding. Timber has been logged in swaths damaging to watersheds. Land damage has been accompanied by accelerated air and water pollution as the result of failure to control, treat or recycle waste effluents from urban and industrial sources.

Until quite recently, the aesthetic values of scenic quality, clean air and clean water were considered desirable luxuries but secondary to economic development and growth. On most public lands, to be sure, and on some private lands, modern methods of forest regeneration, soil conservation, recreational land use planning, and range management have been effectively applied so as to conserve the resource base. But lacking any workable technique of measuring aesthetic values, technicians engaged in resource management were simply unable to consider or to control some of the important environmental results of resource use and management.

Environmental quality is such a broad and all-inclusive concept that it is well to consider precisely its application not only to public lands but to all lands and water resources. The natural landscape--its marshes, hills, valleys, lakes, streams and river drainage systems, forests, grasslands, rocky ledges and ridges and mountains--provides the basic physical and environmental resources used by man for living space and from which to extract his material needs. In ecological balance even under nomadic primitive and subsistence societies, the natural environment has suffered severe ecological dislocations with the impact of Western civilized man's technology.

IMPACTS OF MAN AFFECT ENVIRONMENTAL QUALITY

Modern man's modifications and damage to the earth's resources were first brought to public attention by George Perkins Marsh 100 years ago in

LIBRARY
Bureau of Reclamation
Denver, Colorado

his book, Man and Nature. Since then these impacts have accelerated in intensity and number so that most of the native landscape, waters and air have undergone major alterations. Huge cities have spread out, farm lands have replaced native prairies and logging in forests, drainage of lowlands, transportation system construction and mining have wrought such great changes that little is left of untouched nature. Yet, much of that which man has affected is still relatively resilient from an ecological standpoint.

The task facing the public land manager is to gain greater understanding of the environmental resources in his charge and with this information to so modify future uses of these resources as to fit them within the ecosystem by causing the least possible damage, and if possible to enhance it. This means that future impacts must be anticipated and environmental effects calculated before action is begun. The planning and decision-making processes which until now have involved only engineering and economic efficiency standards, must also be broadened. Most of this report is devoted to a presentation of the techniques needed for establishing environmental and ecological criteria to be used in weighing development plans and decisions.

Before examining the techniques needed for measuring environmental quality, it will be important to examine the types and probable dimension of the impacts in prospect. All are derived from man-made developments or disturbances which change the character of the landscape, air, water, or living resources. In large measure the impacts are economic in origin, in either associated with raw material extraction or developmental construction. Lesser but difficult impacts result from intense recreational uses of public lands, a large group ranging from snowmobiles to "rock hounds". Both classes are growing rapidly so that projection of their uses is necessary to give us some concept of their future effect on land resource. It is of first importance to classify into groups the principal kind of activities likely to cause environmental problems.

Chapter II

IMPACTS ON PUBLIC LANDS

Most of the public lands have been altered to some extent by man's use of them, especially during the past century. Even heavier impacts can be expected in the decades ahead. Three aspects relating to public lands management under more intensive use must now be considered:

1. Restoration of areas previously damaged by exploitative or extraction uses;
2. Control over current and future uses so as to fit them into the public land environment with the least possible damage or, where heavy damage is inevitable, to determine whether such use should be made at all; and
3. Projection of future impacts based upon economic growth forecasts so as to ameliorate potentially damaging effects.

ECONOMIC VS. ENVIRONMENTAL LAND USE PLANNING

In the past and up to the present, decisions to carry out a use of the public land have largely been based on economics -- need or hope of gain. Added to economic efficiency as one determining factor has been technological and engineering efficiency -- both relatively short term, private criteria measured by tangible "cash flow". The long run, social and intangible non-cash costs and benefits have been given little or inadequate consideration in the decision-making process.

Much of the present environmental damage is the direct result of failure to consider social and ecological losses on public lands from such activities as too intensive grazing, strip mining, improper logging practices resulting in erosion and watershed damage and improper disposal of wastes. Location of highway, powerline and pipeline routes in straight (low cost) rights of way has often blemished scenic quality and created soil erosion.

ECONOMIC DEVELOPMENTS DIRECTLY AFFECTING THE ENVIRONMENT

In the chart (4) shown below and in the table (following pages), projections of the important types of economic impacts with the environmental effects are set forth.

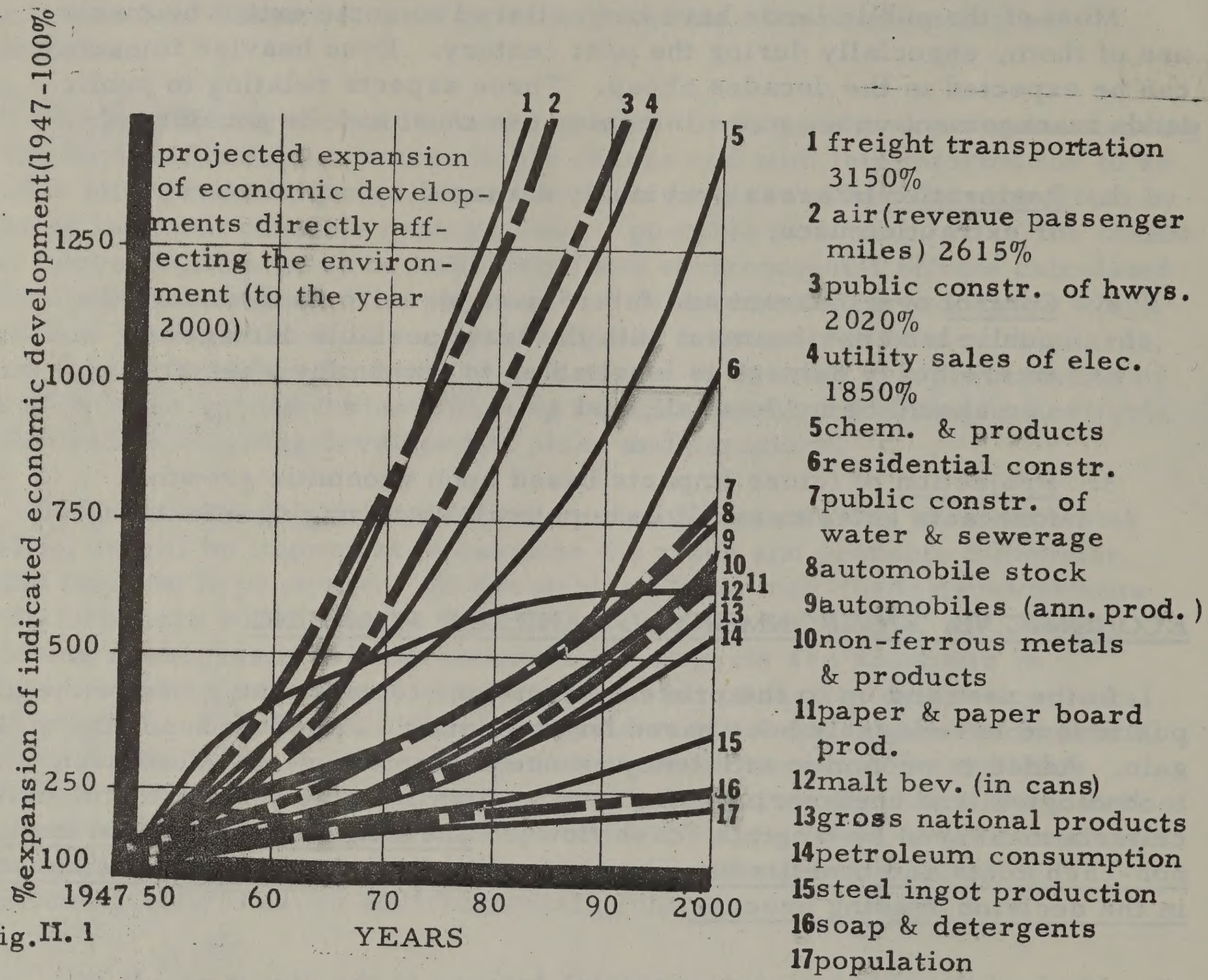


Fig.II. 1

Note: The above chart is based upon the medium assumptions of economic growth between the years 1960 and 2000, using actual data from 1947 to 1960. The base year (1947) was chosen as the starting point since it represents the first year following World War II of reconversion to a "civilian" economy.

---

(4) Defined from data published in Resources in America's Future, Landsburg, Fishman and Fisher. Published by Resources for the Future, Inc., Washington, D. C. 1963.

PROJECTED EXPANSION OF ECONOMIC DEVELOPMENTS(5) DIRECTLY AFFECTING THE ENVIRONMENT TO YEAR 2000

(From common base of 1947 = 100)

Industry	1947	1950	1955	1960	1970	1980	1990	2000	Based upon units	
					L 193	263	343	458		
Gross Natl. Product	100	99	122	137	M 203	289	411	599	$1960 (bil)	P. 532
					H 217	341	540	896		
					139	156	172	185		
Population	100	105	114	124	143	169	198	228	People (mil.)	P. 517
					154	192	241	299		
					145	168	185	198		
Soap & Detergent	100	105	103	125	149	182	213	246	Lbs. (mil.)	P. 967
					160	207	258	320		
					128	136	152	165		
Steel Ingot	100	114	138	117	167	208	266	348	Tons (mil.)	P. 299
					210	299	434	655		
					233	295	365	452		
Automobiles (annual prod.)	100	187	222	187	247	354	497	728	(mil.)	P. 570
					301	517	930	1758		
					213	278	354	440		
Paper & Paper-board Production	100	115	143	163	232	330	460	632	Tons (mil.)	P. 707
					241	379	630	965		
					199	242	296	366		
Total consumption of Petroleum	100	117	151	172	223	293	392	543	(Bbl. (bil.)	P. 578
					253	376	566	876		
					348	460	601	767		
Chemicals & Products	100	133	196	267	430	648	968	1414	$1960 (bil.)	P. 576
					568	1046	1883	3339		
					452	664	897	1217		
Utility Sales of Electricity	100	128	221	305	523	857	1262	1853	KWH. (bil.)	P. 582
					664	1158	1834	2938		
					479	538	558	580		
Malt Beverages (in cans)	100	225	303	366	488	559	592	604	Lbs. (per capita)	
					498	581	627	646		P. 692

---

(5) Resources in America's Future, Landsburg, Fishman and Fisher, Published by Resources for the Future, Inc., Washington, D. C., 1963. (Medium level projections 1970-2000), Data abstracted - Charles H. Stoddard.

Industry	1947	1950	1955	1960	1970	1980	1990	2000	Based upon units	
Public Const. of Highways	100	154	249	319	421	532	643	807	$1960 (bil.)	P. 616
					591	942	1392	2023		
					725	1415	2684	5058		
Public Const. of Water & Sewerage	100	155	202	226	273	303	333	364	$1960 (bil.)	P. 616
					333	455	606	803		
					439	667	1000	1439		
Residential Construction	100	157	178	181	226	283	322	438	$1960 (bil.)	P. 617
					329	438	621	1011		
					451	680	1064	2063		
Auto Stock	100	129	172	210	L 287	403	538	707	(millions) cars	P. 641
					M 295	426	598	798		
					H 323	509	813	1167		
Air (Revenue Passenger-miles	100(6)	117	264	402	705	1051	1448	1870	Miles (bil.)	P. 648
					774	1253	1869	2616		
					881	1557	2516	3827		
Intercity Freight Transportation	100	165	240	345	625	850	1050	1150	Air ton-miles (bil.)	P. 651
					725	1350	2300	3150		
					850	2100	5150	12650		
Non-ferrous Metals & Products	100	110	138	132	154	189	243	309	$1960 (bil)	
					206	311	461	699		
					283	516	841	1486		

Fig. II. 1

---

(6) 1949

PROJECTIONS OF FUTURE USE IMPACTS

Expanding and accelerating demands are being made upon public lands for their raw materials and recreational opportunities, as well as their spatial qualities. The study (Fig. II. 2 Page 12) by Resources for the Future, Inc. projects on a nationwide basis the raw material commodity and land requirements that can be expected to the year 2000. In this carefully done work, certain assumptions were necessarily made with respect to populations, economic growth, leisure time, consumer tastes and the shape of society. It is significant that only nine years ago when the basic work of this study was completed, very little attention was given to the generation of waste or its impact as an effluent on the quality of air and water in the United States.

It is useful, however, to select those economic activities which have the greatest impact upon the environment to give an overall perspective of the dimensions of future impacts upon air, water and land resources. In the chart (Fig. II. 1, Page 11) based on the table from the R. F. F. study (page 12) the year 1947 was selected as a common base year and all data for that year was converted to the index figure of 100. The year 1947 was chosen because it represents the first relatively normal post-war year since which there has been a steady upward trend in practically all categories of economic activity. Actual data between 1947 and 1965 has been tabulated and the projected data extrapolated therefrom. Projections of this sort are valuable primarily in giving the dimensions of expected developments rather than a specific target with some degree of certainty.

Interpreting the chart in overall national terms as each sector affects the total environment is aided by the list of impacts alongside of each. The public lands -- although largely located in the West -- do not exist apart from these national influences. For example, air over the public lands in Arizona is now affected by the polluted air of Southern California (automobile and petrochemical pollutants); recreational uses on all public lands (plus attendant litter) are directly related to population and economic growth; oil shale developments offer a potentially serious water pollution problem in the Colorado River; and streams in the Redwood National Park are badly silted by destructive logging on private forest areas in the watersheds above the Park.

NATIONAL IMPACTS OF ECONOMIC AND POPULATION EXPANSION

Over-riding national impacts of economic and population expansion will also be felt on public lands. Specific demands for resource uses of this type were the subject of the special study by Robert Nathan & Associates. This contract study for the Public Land Law Review Commission attempted to translate the gross national demands for resources into quantities of raw materials which will be drawn directly from public lands. Actual acreages of lands directly affected by these demands are not available, presumably because of the wide differences in occurrences of the resource and the intensity of its exploitation. For example, the national forests in Western Oregon and Washington carry five to 10 times the volume of standing timber per acre than those of the Rocky Mountains or Northern Lake States. Oil shale in the Piceance Formation in Northwestern Colorado is shallow on the edges and thick in the center. Acreages affected in each case would vary significantly with the volumes of raw material extracted. Projections of acreages affected by the volumes of raw materials desired are probably not as important as the proportions of total national requirements. These should be made as a part of the future planning process in order to obtain more precise locations and dimensions of impacts.

SOME POSSIBLE NEW USES FOR PUBLIC LANDS

In reviewing past, present and prospective uses of the public lands several aspects of significance emerge. First, there are the broad sweeping movements: historical conquering of the frontier by hunters, explorers, ranchers, settlers and miners during an era now largely embedded in history. This era was followed by the period of active economic development of the natural resources as a source of production, wealth and leisure opportunity. In prospect, can be seen a wholly new set of uses for the federal lands -- not superseding the old completely -- but perhaps taking priority over traditional uses.

Prediction is always a risky business -- since too often we tend to extrapolate past trends -- but two thrusts seem to stand out in the emerging use of public lands. In addition to continued expansion of natural resource use and development, a major new one is the mobility of an expanding population made possible by modern transportation systems. Several aspects in this phenomenon seem to be clear in which living space and available housing are critical factors: (1) longer commuting distances make it possible for residents of rural areas to travel to central towns and cities to work, and (2) new housing is spreading out in fringes along road systems -- not solely in urban clusters.

Present congestions and other difficulties in larger cities and lower costs of living make rural residence appear desirable enough to offset longer commutation. In addition, the same tendency is at work to encourage decentralizing of some footloose and market-oriented types of industry to rural towns. To the extent that public lands lie in the path of these demands, they will be directly affected by this developing pressure. Already in the Western States where most of the federal lands are concentrated these pressures are at work -- especially in the Southwest and Pacific Coastal areas.

The map shown below, when related to location of public lands, gives an indication of the pressure and forms of some of the new pressures.

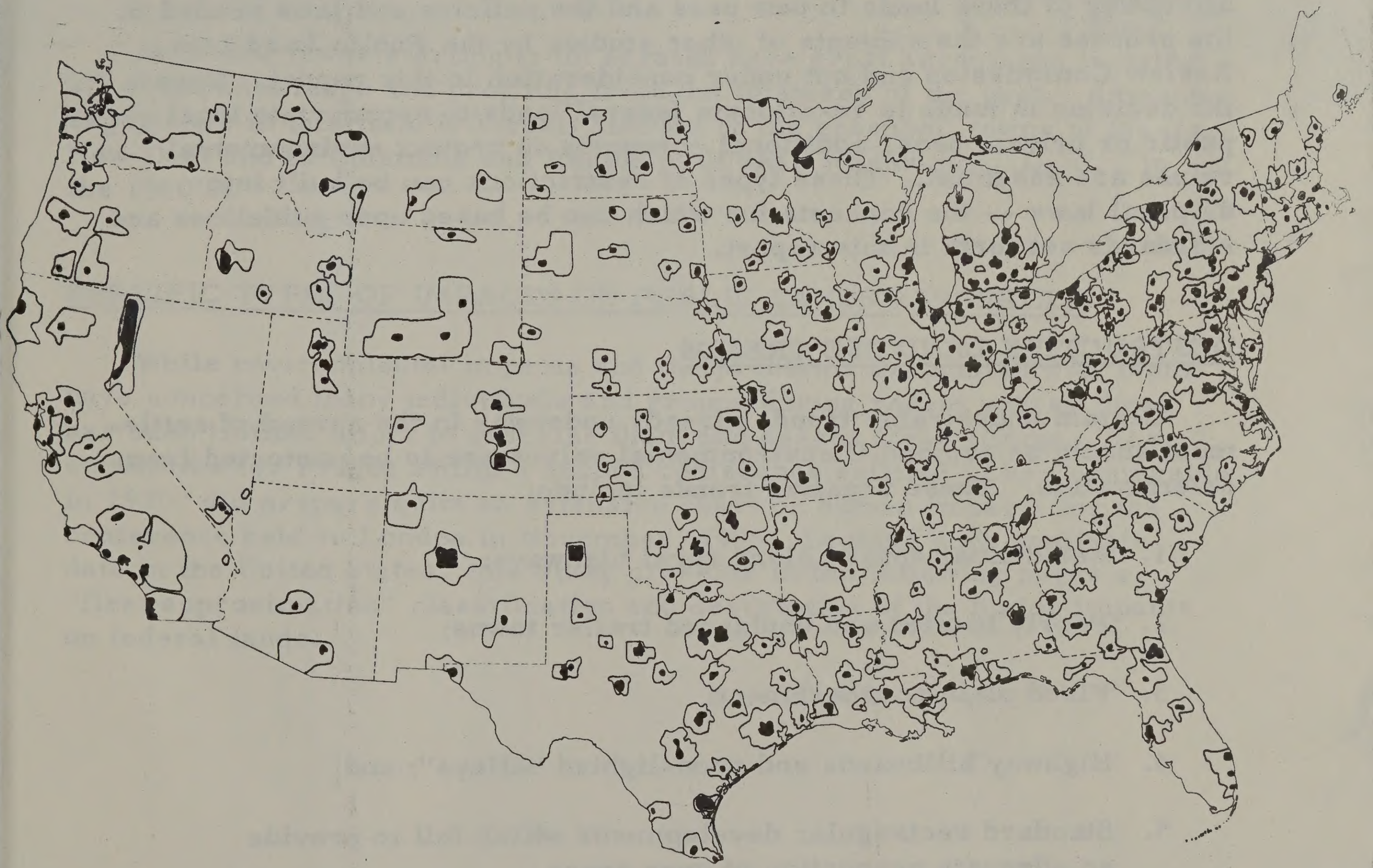


Fig. II-3

II-3

LAND USE CHANGES ON PUBLIC LANDS

Federal lands east of the Great Plains (roughly the 100th Meridian) may be assumed to be generally unavailable for urban or residential expansion. Since these lands have been re-acquired by the U. S. Government for specific purposes -- principally national wildlife refuges, national forests, national parks and recreational areas and military reservations, their dedication to these purposes is unlikely to be shifted by expansion or exploitive pressures. Lands most likely to be subjected to land use changes will be the residual public domain in the 11 Western States and Alaska.

Already underway has been some classification of these tracts near urban areas for disposal under the Temporary Public Sale Act of 1964. A significant requirement of this Act is a satisfactory local area plan and zoning ordinance to assure the best long term use (residential, commercial, public facility or open space). The planning techniques to be used in allocation of these lands to new uses and the policies and laws needed in the process are the subjects of other studies by the Public Land Law Review Commission and not under consideration in this report. Once the decision is made to re-allocate federal lands to appropriate local public or private uses, additional covenants to protect environmental values are essential. These types of restrictions can be built into disposal laws -- the concepts for which can be based upon guidelines and standards set forth in this report.

DESTRUCTIVE LAND USE TRENDS

Certain undesirable trends already underway in the spread of settlement should be avoided if environmental values are to be protected from deterioration. These negative trends include:

1. Residential sprawl along rural highways;

2. Poorly located and unplanned trailer towns;

3. Flood plain encroachment;

4. Highway billboards and neon-lighted "alleys"; and

5. Standard rectangular developments which fail to provide an adequate proportion of open space.

Lack of planning and lack of appropriate land use controls has led to these undesirable situations. Essential to effective environmental protection is the requirement that decisions made for land changes be based on careful plans supported by zoning ordinances, subdivision regulations, sanitary codes, etc. Where public lands are to be disposed of for local private or public purposes, an environmental quality analysis should be used to measure the effect of planned uses.

Finally, in addition to expansion of the larger existing urban centers (made probable by factors already discussed) there is the prospect of wholly new cities as an alternative to further expansion of already crowded existing major cities. Several proposals of this type are now being studies. An example: Minnesota planners have begun a study of the feasibility of a new town in an area west of Minneapolis that would not be economically dependent upon Minneapolis.

Such new towns starting from scratch have great advantages in using all of the knowledge and profiting from the mistakes of the past. American experience in this field is largely limited to the greenbelt towns of the New Deal and to Columbia and Reston built near Washington, D. C., in the 1960's.

SPECIFIC TYPES OF IMPACTS ON PUBLIC LANDS RESOURCES

While environmental impacts and the problems associated with them have concerned many individuals and groups during recent years, there has been limited effort to describe them and assess their effects. The committee for Prince Philip's second conference entitled "The Countryside in 1970" did prepare quite an extensive chart on human impacts for the conference held in London in November, 1965. Lacking such available data in the United States, this study presents in the following pages a "first approximation" classification and description of the major impacts on federal lands.

CHART OF PRINCIPAL HUMAN RESOURCE-USE IMPACTS ON PUBLICLY OWNED LANDS

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
I. RESOURCE UTILIZATION			
A - Forestry Operations: 1. Logging (clearcutting.)	Unsightly cutover land, watershed and stream-bottom damage, soil erosion and stream siltation--Recent tendency toward it.	Apply more intensive silviculture and individual tree selection forestry; make small clearcuttings blended into forest setting.	Land administering agency through contract timber sales to private firms.
2. Logging road construction.	Overly wide road clearing, deep cuts and fills, straight systems without attention to scenic quality.	Build narrower, winding, scenic roads (one way or with turnouts). Avoid areas of sliding soils.	Similar to above with road construction in sale terms but also roads constructed by contractors for land agency.
B - Mining Operations: 1. Exploration for oil and minerals.	Heavy equipment hauled over jeep trails results in uncorrected erosion. Severe scars remain at test sites.	Require site restoration re-sloping and revegetation; close off all trails.	Leases; mineral exploration permits (Act of 1920) Mining claims (Act of 1872) granted to private firms by administrative agency under terms of Acts--1872 Act provides no control over claims.
2. Drilling and extraction--underground mining.	Operation sites usually unsightly, poorly planned, tailings improperly disposed and general litter; acid pollution spills; subsidence.	Adopt tighter controls over operations with adequate enforcement personnel.	Similar to above B 1.
3. Surface mining (strip)-(coal, phosphate and quarrying stone) (Including working of mining claims).	Large areas scarred, often irreparably on slope lands; watershed damage and stream siltation results; acid pollution of streams.	Avoid strip mining of steep lands and replace by shaft; require levelling and revegetation replacement of "divots" on more level lands, or require conversion of land to new uses for lakes, recreation, etc.	Similar to above B 1.

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
4. Placer mining.	Stream bottoms gouged up with rows of gravel left along edges--ruined environment for fish and aquatic life.	Prohibit stream bed mining.	Similar to above B 1.
C - Livestock Operations: Grazing (particularly overgrazing)	Exposure of soils to erosion; replacement of climax grass and forbs with weed species -- Result of grazing beyond capacity of grass growth.	Reduce grazing to carrying capacity of grass; install "rest rotation" grazing; reseed overgrazed ranges. Design cleared blocks (especially in Pinon-Juniper) to blend in with contour of land; leave blocks and strips for wildlife and livestock cover as well as scenic variety; reseed along contour.	Grazing allotments under Taylor Grazing Act (public domain land) and various Forest Service authorities.
II. SURFACE SPATIAL USES A - Transportation Systems: 1. Inter-State Freeways. 2. State Highways. 3. Public land access roads.	Clash with scenic values and do not blend with landscapes; alignments too straight; cut off natural drainage systems; destruction of wildlife habitat; major source of air pollution and chemical control sprays; siltation of streams and rivers.	Improve route selection system by more careful alignments choice; require planning participation by agency landscape planners; landscape completed roadway.	U.S. Department of Transportation (Bureau of Public Roads) with state highway commissions. Land administering agency dominated by these two agencies.
4. Billboard advertising.	Offensive eclipsing of scenic views.	Eliminate all but local informational signs.	Land administering agency.
B - Utility Transmission Lines: 1. High voltage electric lines.	Destruction of trees and scenic vistas in wide, unsightly swaths; failure to "fit" into existing road and railroad developed corridors; wires and electric induction may affect bird movement.	Similar to II A 1-3 above with underground burial of wires wherever possible.	Utility with land administering agency, Federal Power Commission and State regulatory commission with secondary role on part of land administering agency.

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
2. Oil and gas pipelines.	Similar to above plus damage causing erosion at stream and river crossings.	In addition to II A 1-3 above tighter controls needed over contract construction and engineering crews.	See above.
C - Solid Waste Dumps:	Unsightly depositions unless properly located. Source of air and water pollution if adjacent to stream and waste is burned.	Land administering agency can control location; state pollution agency can control burning.	Administrative land agency through permits to local municipalities -- Under state laws.
D - TV, Radio and Telephone Relay Towers:	Occupancy of highest peaks and scenic points with towers-roads and power lines to serve.	Preserve most scenic peaks from non-use; locate towers in clusters.	Land administering agencies.
E - Atomic Energy Commission Test Sites:	Underground testing (earth level and atomospheric testing banned by treaty) with unpredictable impacts.	Halt new testing until thorough reviews by the scientific community can be completed.	Now A. E. C. and Congress.
F - Military and Defense Installations: Training Proving Grounds Air Fields	On both military reservations and public domain lands used for artillery proving grounds, maneuvers, ammunition and chemical warfare tests, airfield operations: Often damaging to landscape, wildlife and vegetation accompanied by litter.	Reduction of vast military land use to minimum requirements through review of military budget and policies. Accelerated litter collection in S. W. and Alaska.	Department of Defense military officials with little or no civilian control.

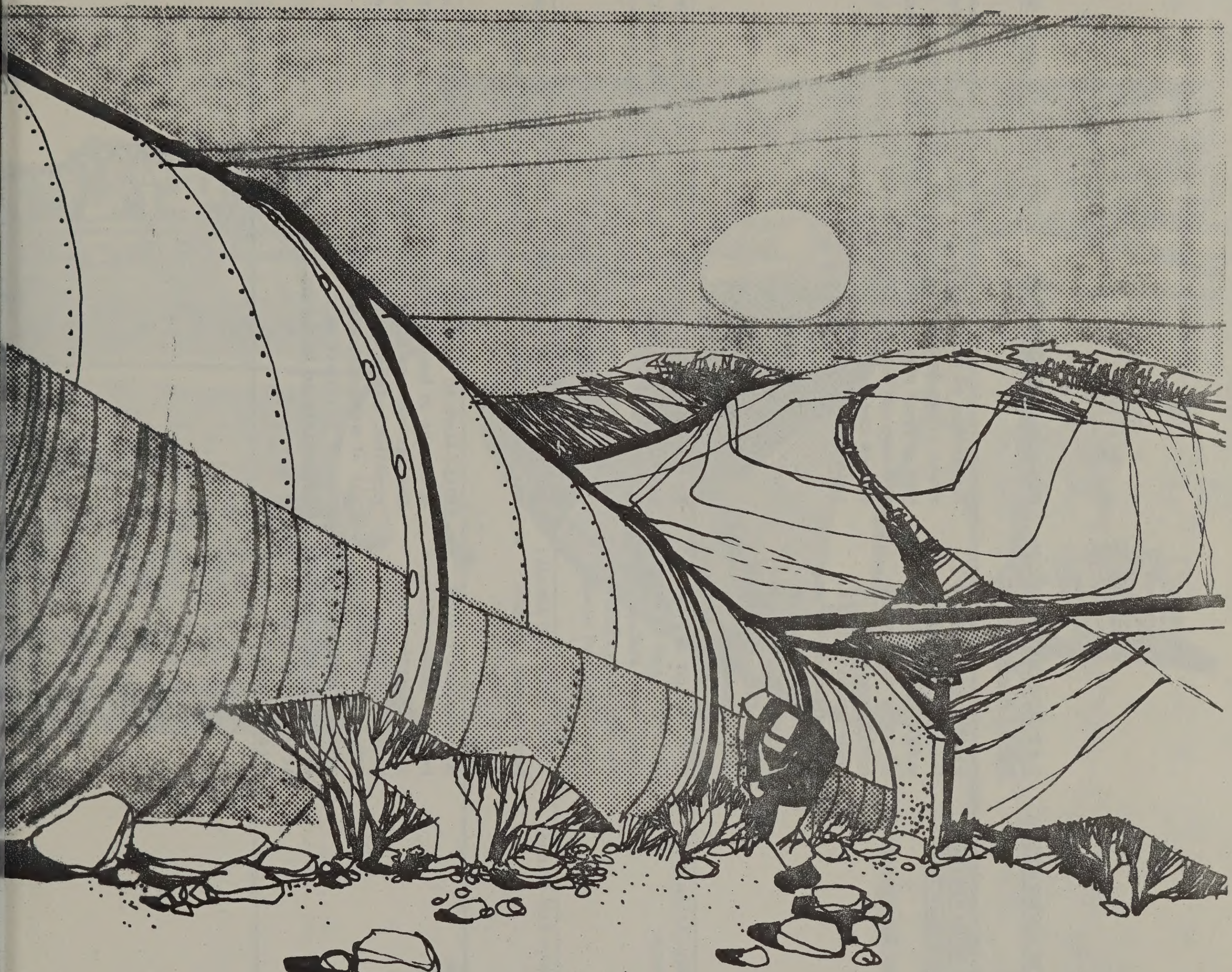


Fig II. 4

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
III. OTHER RESOURCE DEVELOPMENTAL USES A - Dams and Reservoirs:	Flooding of bottomlands, eliminating wildlife habitat (and creating new waterfowl areas) loss of shite water; alteration of scenic values; water temperature changes; fish migrations blocked; loss of bottomlands to agriculture.	Reserving of some wild river areas from damming; proper planning to enhance environmental values created by reservoirs.	Land administering agencies lost control to Corps of Army Engineers and Bureau of Reclamation.
B - Urban Expansion and New Towns:	Conversion of rural and wild land to urban uses--can and often results in serious environmental and social problems.	Requires careful advance planning.	Some state, county or metropolitan planning agencies -- often no central responsibility.
C - Open Space and Parks:	Areas often too small; tend to concentrate recreational uses. (See IV-A)	Increase size of areas for recreational use.	Local and state planning and parks agencies.
D - Drainage:	Accelerates runoff; reduces water storage and infiltration into ground; lowering of water table; silt production increased; downstream flood potential accelerated by channel straightening.	State laws to restrict drainage to bottomlands for agriculture and prohibit upland drainage of wetlands; acquisition or purchase of easements on wetlands.	State and local soil conservation and drainage districts; U.S. Soil Conservation Service; landowners themselves.

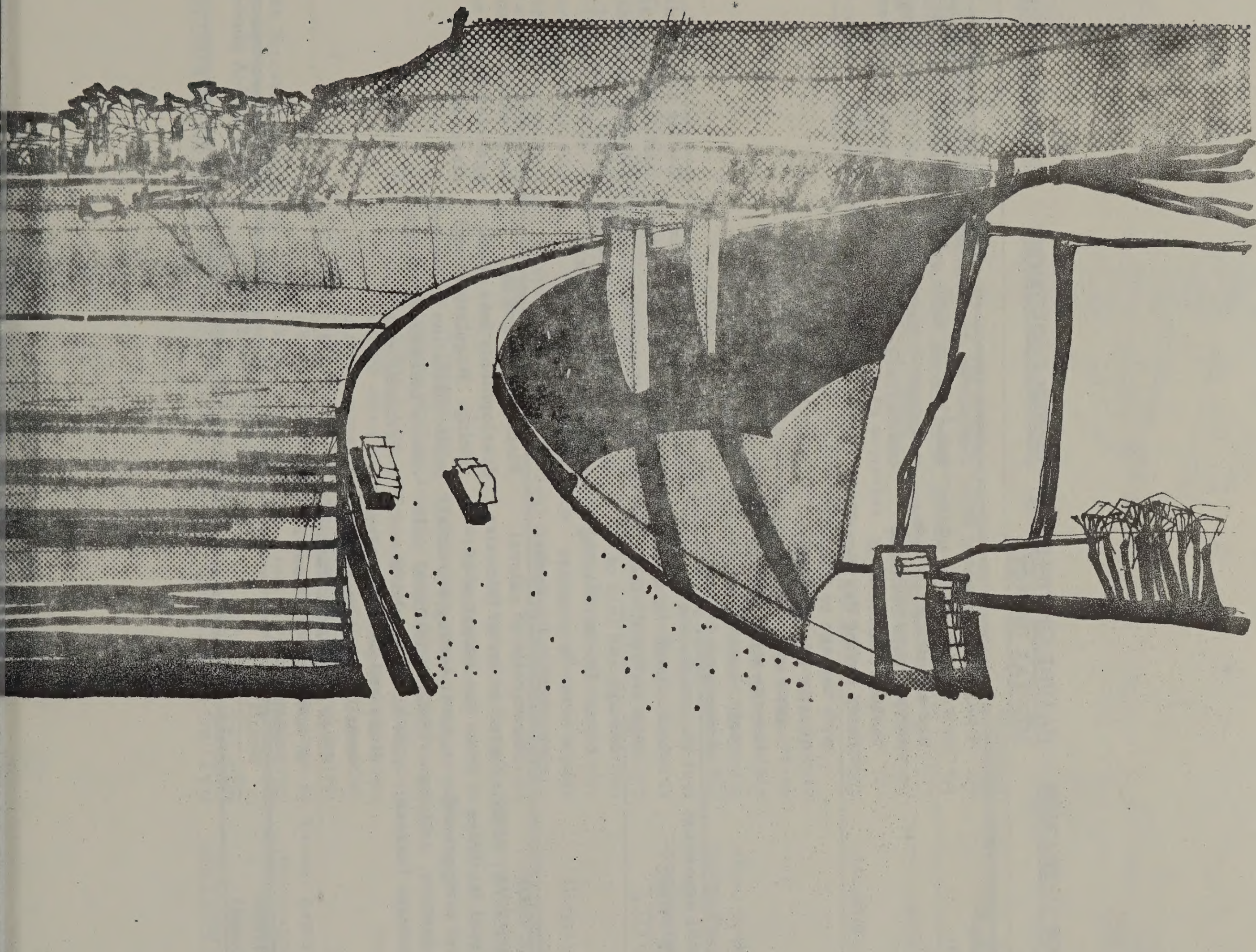


Fig. II.5

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
E - Irrigation:*	Where ground water in S. W. used, water tables are shrinking; stream withdrawals result in serious reduction of flows during dry months with damage to fish and aquatic life; tendency toward saline concentrations in soils; use of toxic chemicals pollutes downstream water.	Use stored (in resevoirs) flood waters only; manage irrigation to dissolve saline concentrations.	State laws and local irrigation districts; U.S. Bureau of Reclamation and Soil Conservation Service; landowners.
F - Residential expansion on flood plains:*	Encroachment of river bottomlands by dwellings inevitably leads to damage and loss of human life by flooding in areas of greatest recreational potential.	Zone against flood plain use except for agriculture, parks and open space; do not build flood protection or control resevoirs.	Zoning and acquisition of lands by local park and planning agencies; U.S. Army Corps of Engineers.
IV. SERVICE (NON-CONSUMPTIVE) USES. A - Recreational facilities (intensive) campgrounds, service centers, activity areas, cottage lessees:	Conversion of natural area to one of intensive use (maintenance of natural setting essential) --Soil compaction, wildlife habitat disburbance, litter and waste problems, erosion and damage to trees and plants; radio, tv and motorboat noise nuisance.	Planning to blend in developments into scenic setting. Regulations and public education to control visitor movement and use -- campsite rotation.	Land administration agencies design and construct facilities.
B - Road Systems: (recreational)	See II-A	Carefully designed scenic and 1-way roads.	Same as I-A above.

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
C - Extensive Recreational Uses (not included above): Hunting Fishing Rock Hounding Trail Riding Overland Motor Vehicles Snowmobiling Water Sports All others	These and a wide variety of other recreational visitor uses have various impacts: trampling, litter, waste disposal, sanitation problems, horses (feed, sanitation and trail wear); forest fire risks, disturbance to birds and animal species requiring solitude for reproduction.	Use of self-guiding nature trails, identified use areas under supervision, enforcement of litter regulations, strict control over vehicle movements off roads.	Land administering agency.
D - Research and Educational Activity	Archeological and watershed (clearing) work often disturbs ecology and cultural values.	Through advance planning and careful controls by land administering agency.	Land administering agency in cooperation with user research and educational groups.
V. ADMINISTRATIVE MANAGERIAL OPERATIONS A - Resource Management: 1. Rehabilitation of range lands:	Land clearing and brush spraying in large rectangular blocks; reseeding to palatable grasses. Work often leaves landscapes with scarred appearance. Reseeding not on contour results in gullying.	Design cleared blocks (especially in Pinon-juniper) to conform to contour of land. Leave tree strips and blocks for wildlife and livestock cover as well as scenic variety. Reseed on contour.	Administrative agency with contractor.
2. Timber Stand Improvement:	Often done with mechanical efficiency, leaving brushy and scarred appearance.	More individual tree selection by trained manpower.	Administrative agency with direct labor.
3. Reforestation:	Machine planting often off contour causing gullying.	Advance grade staking with hand level.	Administrative agency with direct labor.

Table II.1

ACTIVITY OR OPERATION	NATURE OF ENVIRONMENTAL IMPACTS	POSSIBLE SOLUTIONS	DECISION-MAKING SOURCES
B - Resource Protection: 1. Forest fire protection.	Forest fires resulting in serious devastation.	More effective fire control planning training and equipment.	Administrative agency.
2. Insect & disease control.	Loss of timber & unsightly appearance of defoliated and dying trees. Use of insecticides has caused serious ecological effects.	Research to find biological controls. Cease use of chlorinated hydrocarbons or other toxic insecticides. Remove infected timber.	Administrative agency.
3. Natural Causes.	Windstorm, wildlife damage, etc.	None known.	
C - Resource Development: Channel straightening, ditching, bank repair, roads & a wide variety of related land disturbances.	Often results in new erosion and siltation of waterways.	More careful advance design and in some cases refraining from carrying on projects where damage too great.	Administrative agency.

* These uses are on lands classified for disposal by public agencies; disposal conditions can be used to control future uses.

I. EXTRACTIVE RESOURCE UTILIZATION

As suggested in the foregoing chart, the principal resource use impacts on public lands involve harvesting or removing vegetation or mineral resources.

Forestry Operations (including logging and road construction)

Felling trees, skidding logs, clearing areas for log decks (piles) and road construction are disturbing to the forest environment in many ways. Soils are disturbed, shade removed and land opened to drying sun and winds, and cover useful in retarding runoff is destroyed. Log skid trails promote erosion and damage to stream beds. Logging roads on hill and mountainsides, if over-engineered or built on soils which slough easily, cause serious slippage and damage to watersheds. On the other hand, wildlife habitat can be benefited by changing ecological stages of the forest succession.

Damage to the forest environment (especially soils and cover) has been aggravated by recent developments in heavy logging and road building machinery. In place of light frequent selective cuttings (dictated by intensive silvicultural techniques), heavy clear cuttings have been commonly applied on both federal and private lands. Although re-planting is now commonly carried out, restoration of the damage by skidding and roads and to stream bottoms has been seriously neglected. This problem is particularly serious in the Coastal Range of Northern California and Oregon in the Redwood and Douglas fir forests.

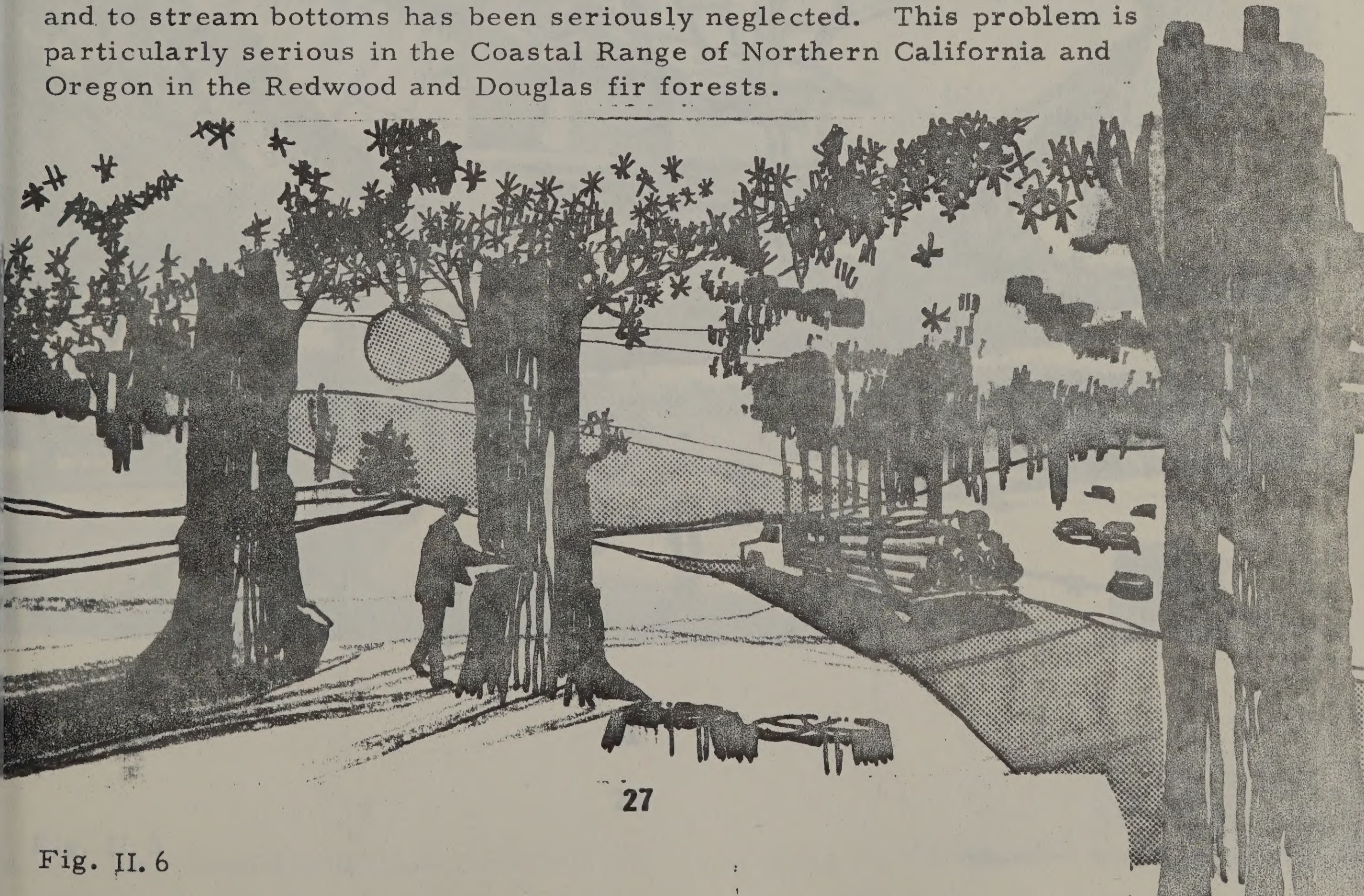


Fig. II. 6

Mining Operations

The types of land disturbance from mineral exploration and extraction vary considerably by the nature of the deposit and the processes used for exploitation. (Outer Continental Shelf oil production is a separate problem which has been considered beyond the ken of these reports.)

Probably the most extensive damage done by mining is the relatively new strip (surface) method now used in coal and phosphate and projected for oil shale. Large areas are stripped of surface "overburden" and windrowed to allow for excavation of mineral deposits. Restoration of the surface is possible by replacing overburden into spent pits, grading and revegeting these. Under present regulations this is not done--although the cost of this rehabilitation has been found to be a small fraction of the value of minerals removed.

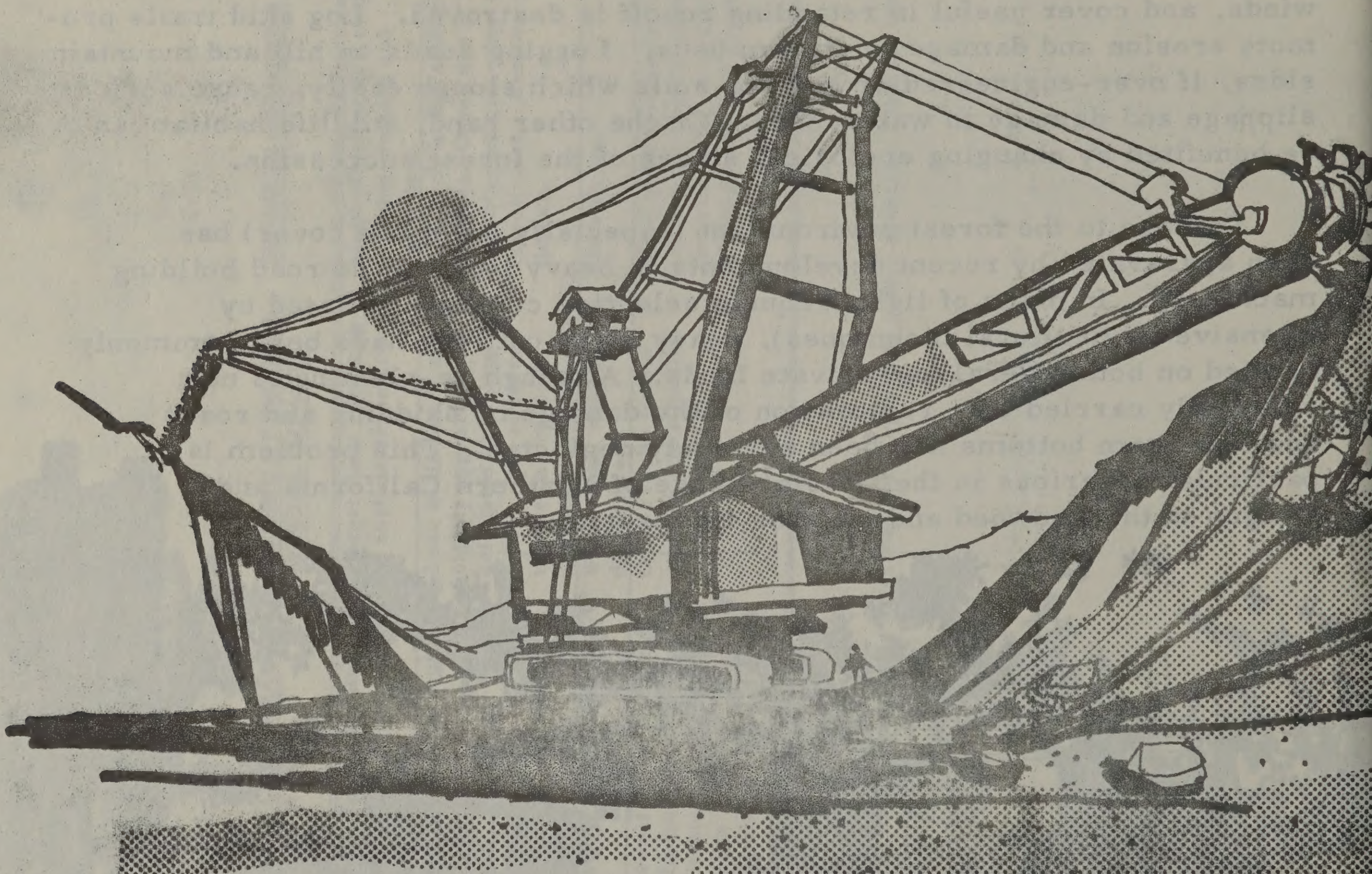


Fig. II. 7

Exploration crews for oil concerns and mining claimants do intensive work on relatively small areas (all repairable), but their greatest impact comes from transporting heavy equipment over roadless plains, tundra or desert lands. Frequently, these rutted truck trails become catchments for running water which then concentrate it into eroding gullies. Inadequate regulations have not given land managers the power to require use of existing roads, construction and maintenance of new roads (when needed) or to place appropriate responsibilities upon both the principal and its contractor.

Livestock Operations

Although grazing animals have a traditional role in the ecology of grasslands (buffalo, elk, etc.) overgrazing by domestic livestock has brought on serious erosion and forage degradation problems -- especially on the public domain lands as a result of inadequate administrative controls (especially by BLM). Much of the problem can be arrested by applying rest-rotation management and re-seeding in heavily depleted areas. In the latter case care must be given to drilling seed (and brush clearing if needed) on the contour to prevent eroding of soils.

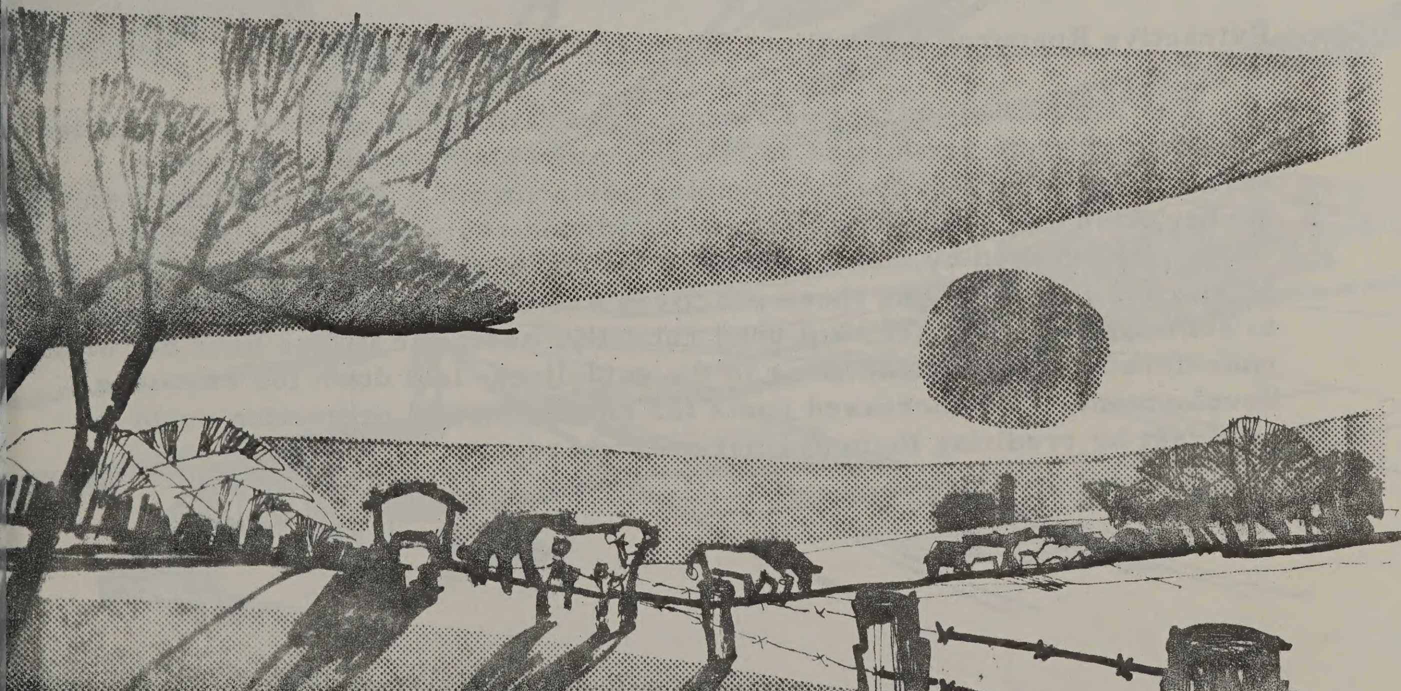


Fig. II. 8

Extractive Resource Utilization Decision-Making

Extractive resource utilization on public lands is usually carried on under a permit or lease system that stipulates the conditions under which the resources may be developed and the fees paid. In forest operations, trees may be marked under regulations prescribed in a management plan; lands to be grazed will be allocated according to carrying capacity -- both under control of the land administering agency.

Leased minerals are extracted under regulations prescribed and administered by the U. S. Geological Survey which can function unilateraly and independent of the land administering agency. This arrangement has not always provided adequate safeguards or environmental protection standards. (The Santa Barbara oil disaster took place after the U. S. G. S. had assumed supervision over Bureau of Land Management leased minerals.)

In all these situations the control of the land administering agency depends upon the adequacy of regulations and the manpower available for their enforcement. The operational use of the resource is carried on by the lessor or purchasers, not the land administrator. Since another special study by the Commission covers this topic in detail, it has been given recognition here only as an issue related to environmental impacts.

Extractive Resource Utilization: Summary

The impacts of extractive resource operations which have been carried on with maximum production as the primary objective have often been seriously damaging to the surrounding environment. Watershed and scenic quality, fish and wildlife habitat and continued resource productivity are frequently reduced by commercially efficient exploitation. Well-developed techniques for modifying these practices are available and have been applied to some public land uses, but until recently, aesthetic values have not been considered necessary additions to the guidelines laid down for resource development. The increased costs for environmental protection could be offset by crediting them against user charges.

II. SURFACE (SPATIAL) LAND USE

This broad group of uses on public lands are essentially non-consumptive of the land resource but alters its appearance markedly. Usually easements or rights to use are granted by administrative land agencies rather than transfer of title.

Fig. II. 9

The impacts of these uses (transportation systems, utility transmission lines, solid waste dumps, billboards, TV and telephone relay towers, A. E. C. test sites and military installations) significantly affect the scenic quality of the land and often preclude other uses. Nearly all are certain to grow in number and acreage required with the exception of the last two. Any expansion of traditional military activity is not expected to use more land, and A. E. C. above ground nuclear testing is now prohibited by international treaty.

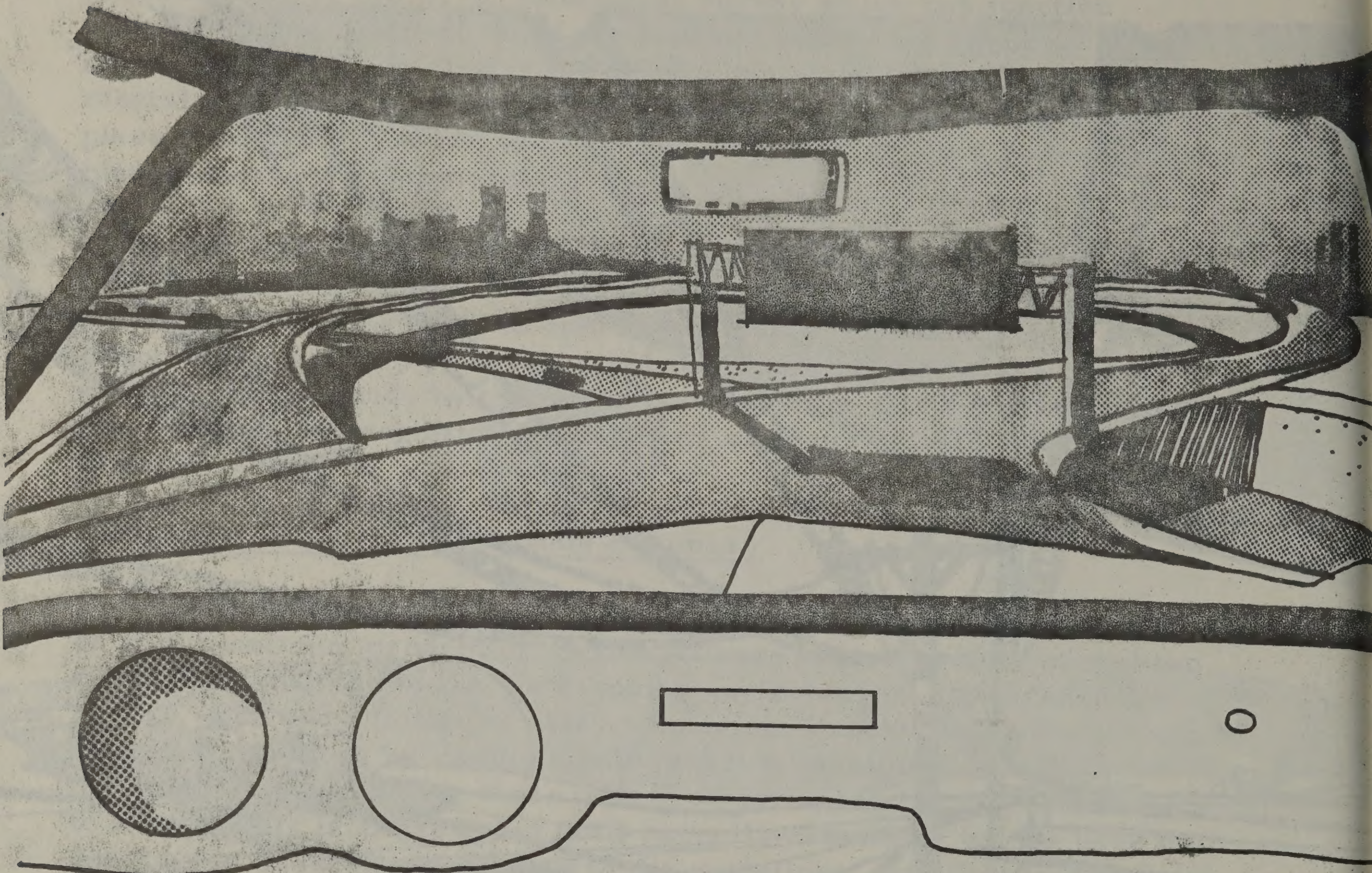


Fig. II. 10

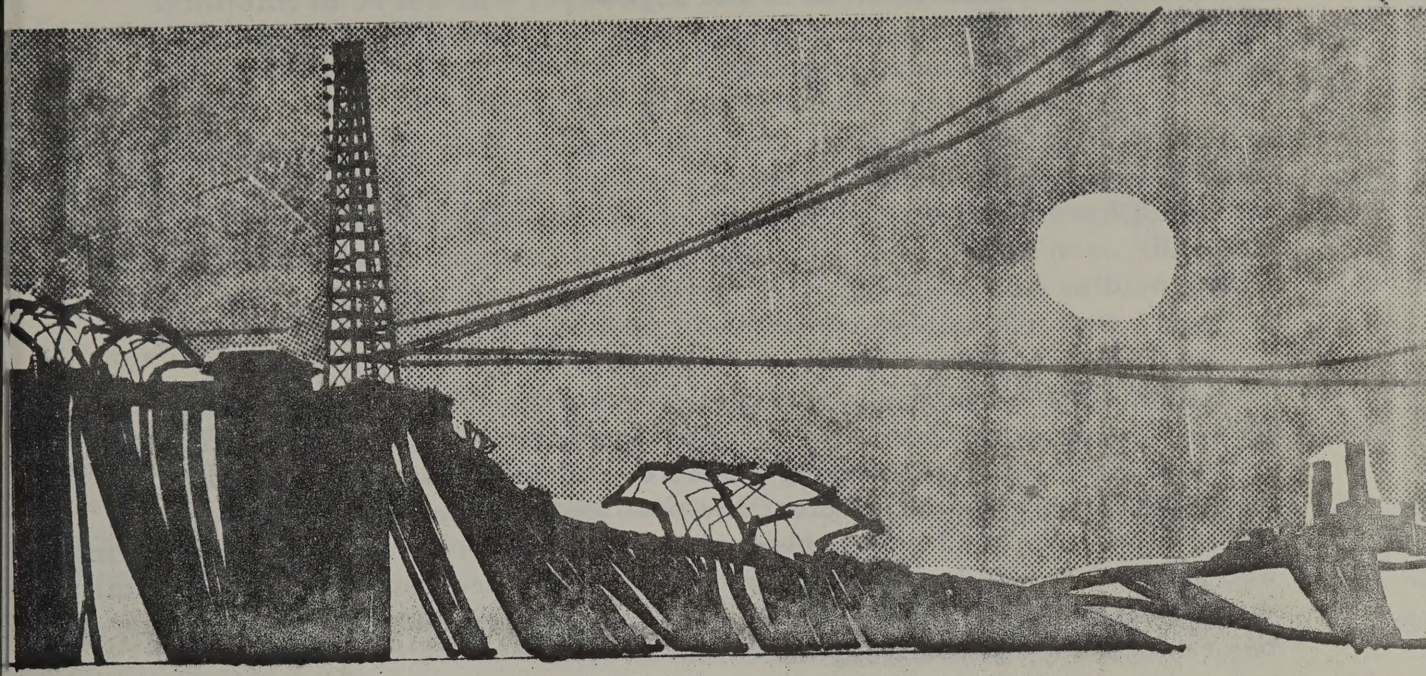


Fig. II. 11

Administrative agencies have exercised minimal control over these uses -- even to the extent of indicating where the use may or may not take place. Thus highways have been constructed along the easiest and straightest routes, power and pipelines have cut deep swaths over hills and mountains, solid waste dumps have been put close to settled areas and communication towers appear on the highest scenic points of interest. Some billboard control has been exercised. Military gunnery and manpower maneuvers have damaged and littered large areas of land in Alaska and in the Southwest. In short, this whole group of uses has been taking place largely without regard to their impacts on scenic or qualitative values.

A few general guidelines can be described for controlling these uses but detailed techniques must still be designed for each individual situation. Any way in which these uses can be blended into the landscape, diverted from scenic situations (hills, river valleys, etc.) and into existing developed corridors (railroads and highways) will serve to minimize their offensive effect on aesthetic eye appeal. Such planning would also make the best use of the land.

Until now, decisions for location of these uses have rested largely upon the agency or concern applying for the use itself. Administrative agencies have not been prepared to provide meaningful guidelines as these demands upon them have mounted. But recent studies and field experience are providing better technical information for managing these new impacts. A recent example is the proposed oil pipeline in Alaska.

Lands for highways and roads, power and pipelines and solid waste dumps in this group are often handled by easements or permits granted by the land agency to the using public or private entity. Until quite recently these permits have not included environmental considerations. The areas to be used were selected by the permittee. Frequently, permits are granted by the land agency without adequate review to environmental quality. One exception in recent years, billboard and sign control, has been exercised by public agencies.

With the newer concepts of environmental land planning based upon an inventory of landscape resources, the opportunity for guiding the location of these developments away from prime select areas and fitting them into the less obtrusive situations presents itself. To accomplish this, planning initiative by the land owning agency is a key element. Prior notification by the prospective permittee of the development, joint planning and final approval by the land agency are steps needed to achieve this change from present procedures.

III. OTHER RESOURCE DEVELOPMENTAL USES

The third broad group of resource use essentially converts land from its natural use to one of greater productivity -- dams and reservoirs, urban residential and industrial expansion, irrigated agriculture, parks and open space (for urban people). Generally, these uses enable the land to support an increasing population. In most cases title to the land is transferred from the federal agency.

In the West the water-related uses, such as irrigated agriculture, will continue to be an important factor. However, many of the large reservoir sites have already been developed. Small reservoirs will be constructed in large numbers to serve new urban areas for municipal water. Thus urban expansion (including "new towns") will probably be a major factor in shifting land use during the next few decades. Until now urban expansion has proceeded in a haphazard manner. Advance planning prior to transfer from federal agencies to local private and public ownership is essential to the most effective future use. It is especially important to prevent encroachment of flood plains of rivers by housing -- both to provide open space and to avoid the need for flood control works.

Drainage, if not properly planned, is likely to continue in both river bottoms and upland marshes (wetlands) as the demand for food and fiber grows. However, wetlands, especially in uplands, serve as catchment basins to store flood water runoff and to infiltrate into the ground water table and provide nesting areas for waterfowl and upland game birds. Flood plain drainage has less hydrological effect by comparison, but such drainage can seriously impair the value of flood plains for open space and park uses.

Use of environmental landscape inventories can be used to guide decisions in this category -- avoidance of special natural or scenic areas from any development, location of power and pipelines along developed corridors, etc. Wetlands can be identified, scenic hilltops located and other special features of the landscape for an initial reconnaissance to be followed by detailed field studies prior to project planning.

Resource developmental uses often take place on lands transferred from the federal public lands -- either to private owners or to state or other governmental agencies. In many cases transfers for this group of uses -- dams and reservoirs, urban expansion, drainage, irrigation and open space have come from the public domain lands administered by the Bureau of Land Management. Except for lands disposed of under the Recreation and Public Purposes and Public Sale Acts (expiring in 1970) conditions have not been included in the terms of transfer for urban open space and developed uses.

The two acts contain interesting environmental features. R. & P. P. requires that the local government accepting the land does so for a defined purpose. Any change in use must be approved by the land administrating agency. (Enforcement and checking up by B. L. M. has been limited primarily because of scarce manpower.) The Public Sale Act provides for a defined use covered by a zoning ordinance prior to transfer or sale for private purposes. In both cases continuous policing of uses by B. L. M. is essential to maintaining the integrity of the conditions of disposal.

Lands transferred for intensive uses such as drainage, irrigation or flood plain occupancy have not been subject to control by the transferring agency. The requirement of advance environmental plans and continual enforcement to assure compliance appear to be workable techniques for all of this group.

IV. SERVICE (NON-CONSUMPTIVE) LAND USES

Service (non-consumptive) land uses are usually associated with developments involving public accessibility and use. Intensively used recreational facilities such as campgrounds, visitor centers, ball fields, beaches, and road systems are one major group. Impacts largely in the summer season (though skiing and snowmobiling is changing even this) include litter and solid and sanitary wastes, soil compaction and plant and tree damage and trampling along with noise and air pollution from motor vehicles and boats, radios, TV's, etc.

The second group of uses are extensive in nature and are often activities emanating from or based in the first. These include hunting, fishing, hiking, trail riding, rock hounding and a wide variety of scattered activities over land and related water resources. Similar impacts are found here as in the first group except that they are not as intensive but are less easy to control and correct.

A third and expanding category are the activities of research and educational groups -- mainly governmental and university agencies. Resource studies in experimental areas and archeological investigations are the primary activities in this area. The fact that they take place under the auspices of public agencies makes initial control relatively easy.

Heavier Impacts Expected

It is to be expected that all of these uses and their associated impacts will become much heavier in the next few decades. Population growth, probably decentralization of urban growth, increase in leisure time and greater mobility all tend to pour more people into public outdoor areas. Since these activities take place under the direct supervision of the administrative agency and since the planning design and construction of supporting service facilities are carried out by the agency, the major problem is the management of visitor use.

Properly designed facilities will influence visitor use movement and make for much greater control than haphazard planning. For example, single lane, one-way scenic drives with low speed limits reduce traffic regulating problems of safety, speed and accidents which are encountered on two or four-lane engineering standard, multiple use roads. Yet up to now, few such roads have been built for recreational uses -- presumably because engineers still control the planning process. Similarly, buildings and campgrounds set back from waterways not only preserve the natural scenic qualities of the shoreline but keep septic wastes from entering rivers and lakes as a pollutant.

V. ADMINISTRATIVE MANAGERIAL OPERATIONS

Administrative Managerial activities (Chart Item V) are entirely land agency-initiated functions over which the administration has full control. In numerous instances, inadequate attention has been given to environmental side effects. The suggestions included in the chart and in later discussion should be included in the guidelines for executing management plans.

THE DECISION-MAKING PROCESS: AN ANALYSIS AND EVALUATION

Previously it has been shown that the uses of the public lands are carried out under laws administered by federal agency personnel. The laws are further implemented and interpreted in agency regulations which set forth procedures and criteria for each kind of use. Ordinarily, it falls to the local unit administrator to carry out these regulations and enforce them with the several kinds of users. In this function he is supported by the great weight of his agency and by a management plan which has been developed to regulate the resource-uses consistent with the agency's stated objectives, e.g. multiple use (National Forests, public domain lands), preservation and recreation (National Parks), wildlife habitat (National Wildlife Refuges), etc.

Agency support of field personnel is carried out through frequent inspections on the ground to determine if regulations are in fact applied, by transfer of personnel to prevent too great involvement and identity with local users as opposed to agency and national interests, promotion incentives to maintain loyalty to the agency and other less apparent devices.

Local Pressures Facing Technical Specialists

Within the guidelines of the regulations the local unit administrator has some latitude; further, because of the variations in the composition of the resource, topography and the needs of the user or plans for proposed developments, additional subjective judgments become necessary. In some cases, highly technical situations arise which must be solved by the man on the ground in a short time. Frequently, he must rely on the advice of the technical specialist employed by the resource user. In some situations strong pressures develop to "keep men employed" or to keep the local industry supplies with new material. Local pressures may even be exerted to keep a locally influential person from vacating an unpatented mining claim on which he has a summer cabin. The decisions about how to handle a given resource operation are made both in the context of guidelines laid down in the public interest and under pressures favoring local interests.

To the extent that management plans with high priority given to environmental factors have been developed (some agencies are much more sophisticated than others) a fairly idealized model for meeting any given resource situation exists. But the application of the regulatory guidelines to each of the resource-use situations described previously will vary directly with the degree of control over the operation. For example, in Administrative Management Operations (Item V in the Chart), the agency in charge has direct line operational control over the field projects. This same situation holds for Item IV (Service Uses) when project planning, design and construction are directly carried out by the local agency or its contractors.

In the case of Item I (Resource Utilization), the agency administrator's control is that which exists between a contractor or lessee and a person awarding the contract. Stipulations, standards and terms may be quite precise but the contractor will seek to maximize immediate cash returns by cutting corners. Therefore, environmental requirements may be sacrificed unless there is very careful and continuous supervision and inspection. (In Michigan the State Department of Natural Resources was faced with arming its conservation officers to force pipeline contractors to live up to regulations). Adequate environmental controls over these types of uses will take additional technical manpower and economic incentives to place an incentive on careful work. Since additional costs are likely, to assure environmental quality, these incentives could include a reduction in user fees or a bonus in the form of additional raw material.

Chapter III

AREAS OF URBANIZATION IMPACT

In reviewing the range of human impacts upon public lands, it is quickly evident that the greatest total impact can be expected where major urban patterns lie close to or touch the public land and where outstanding recreational qualities and mineral wealth occur.

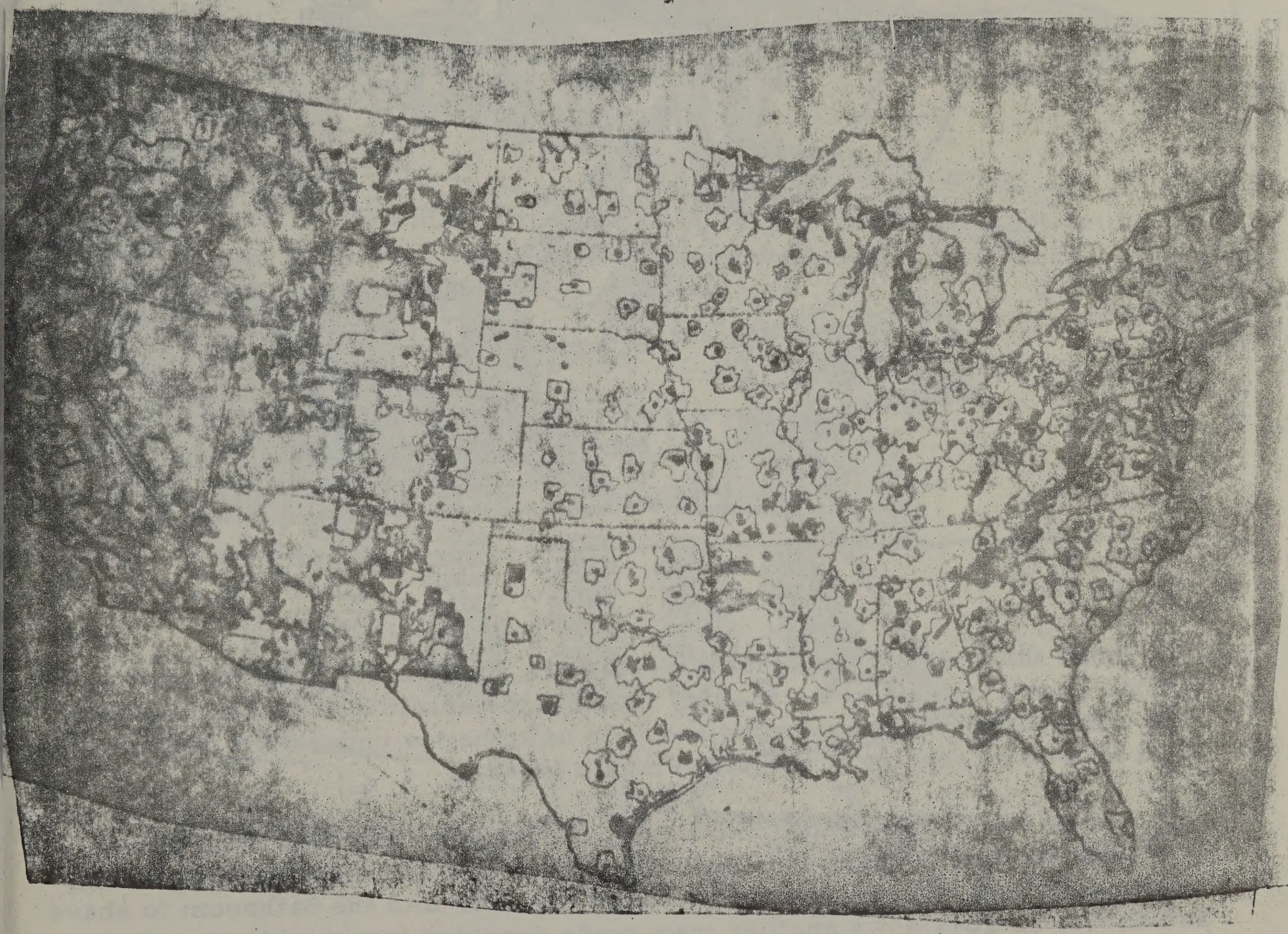


Fig. III. 1

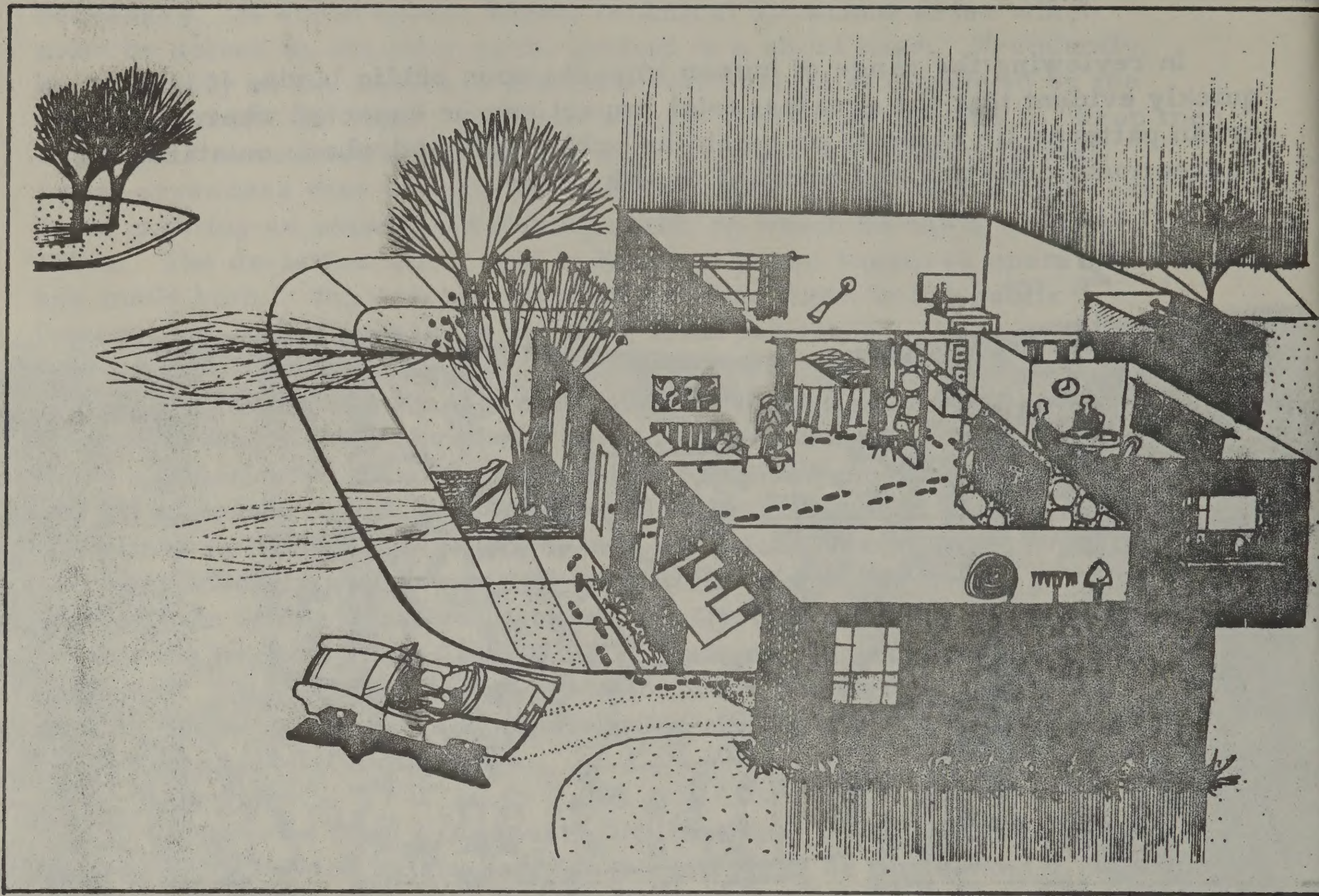


Fig. III. 2

Since the greatest majority of people are and will be living in metropolitan areas, a visit to a U. S. city to study the urbanite in his environment will undoubtedly prove revealing and help us to better understand him, and what he will be seeking in a visit to public lands.

Let us remove the roof from a typical household and awake the householder in his little square cubicle of man-made materials called a bedroom. He stumbles out of bed down a man-made corridor into the bathroom to shave and dress; he goes down another man-made corridor into the kitchen where he gulps his orange juice, toast and coffee; goes down another man-made corridor where he grabs his hat and coat. Then he dashes down a sidewalk corridor either into the garage and a metal cubical called a car or into the crowded public commuter vehicle and he's on his way to work -- all of his movements being controlled by a series of right angles and man-made materials.

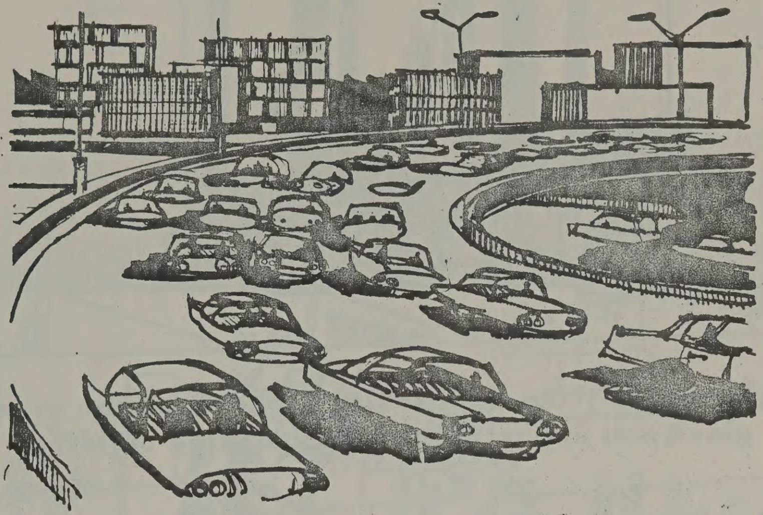


Fig. III. 3

He whizzes toward his destination at 60 m. p. h. elbow to elbow with his neighbors, amidst the exhaust fumes and the screeching of brakes.

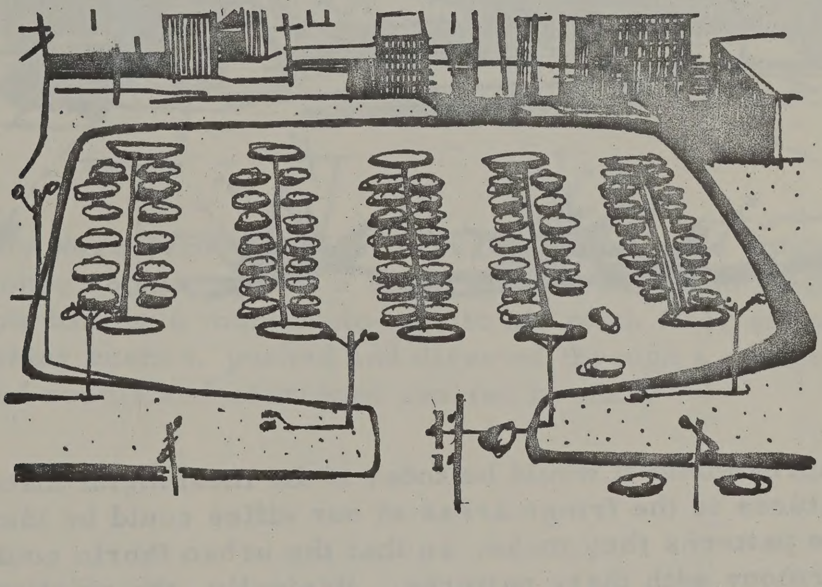


Fig. III. 4

He comes to a halt on a sea of asphalt, either hubcap to hubcap with his co-worker -- or tripping over him.

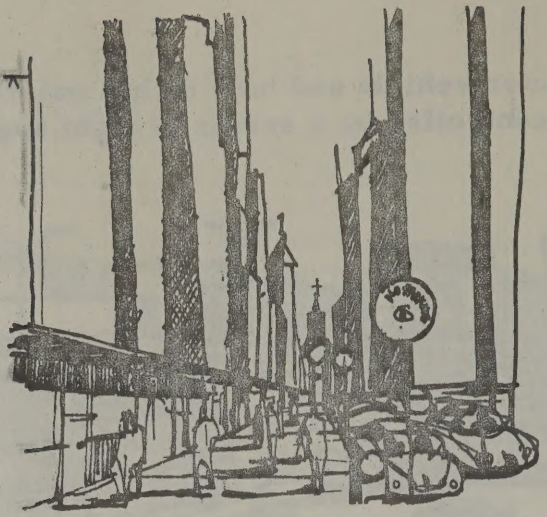


Fig. III. 5

He is then channeled from the parking lot through the great canyons of brick, steel, glass and asphalt, toward his office building.

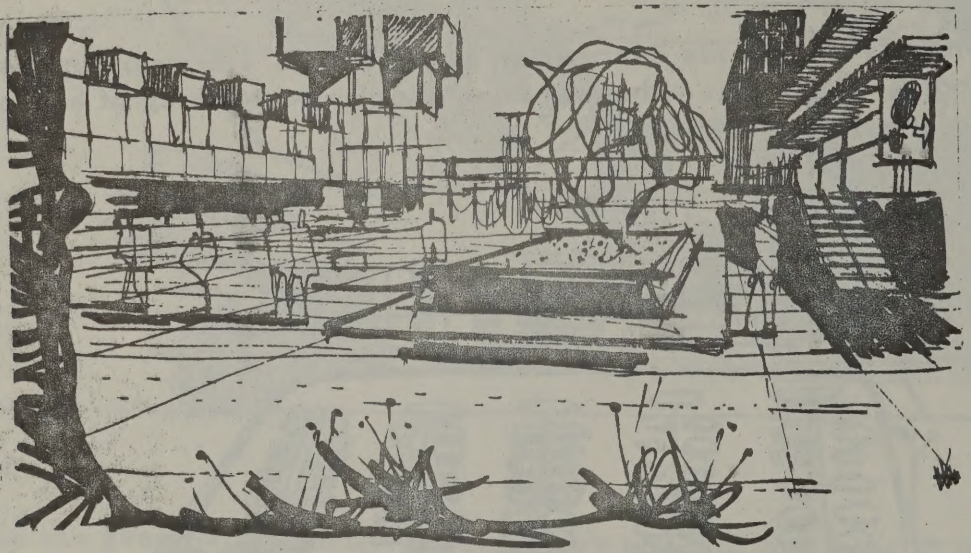


Fig. III. 6

What an improvement it would be today if the meaningful material and cultural features in the fringe areas of our cities could be identified to determine the patterns they make, so that the urban fabric could be developed in harmony with these patterns. Basically, the existing features could serve as urban form determinants.

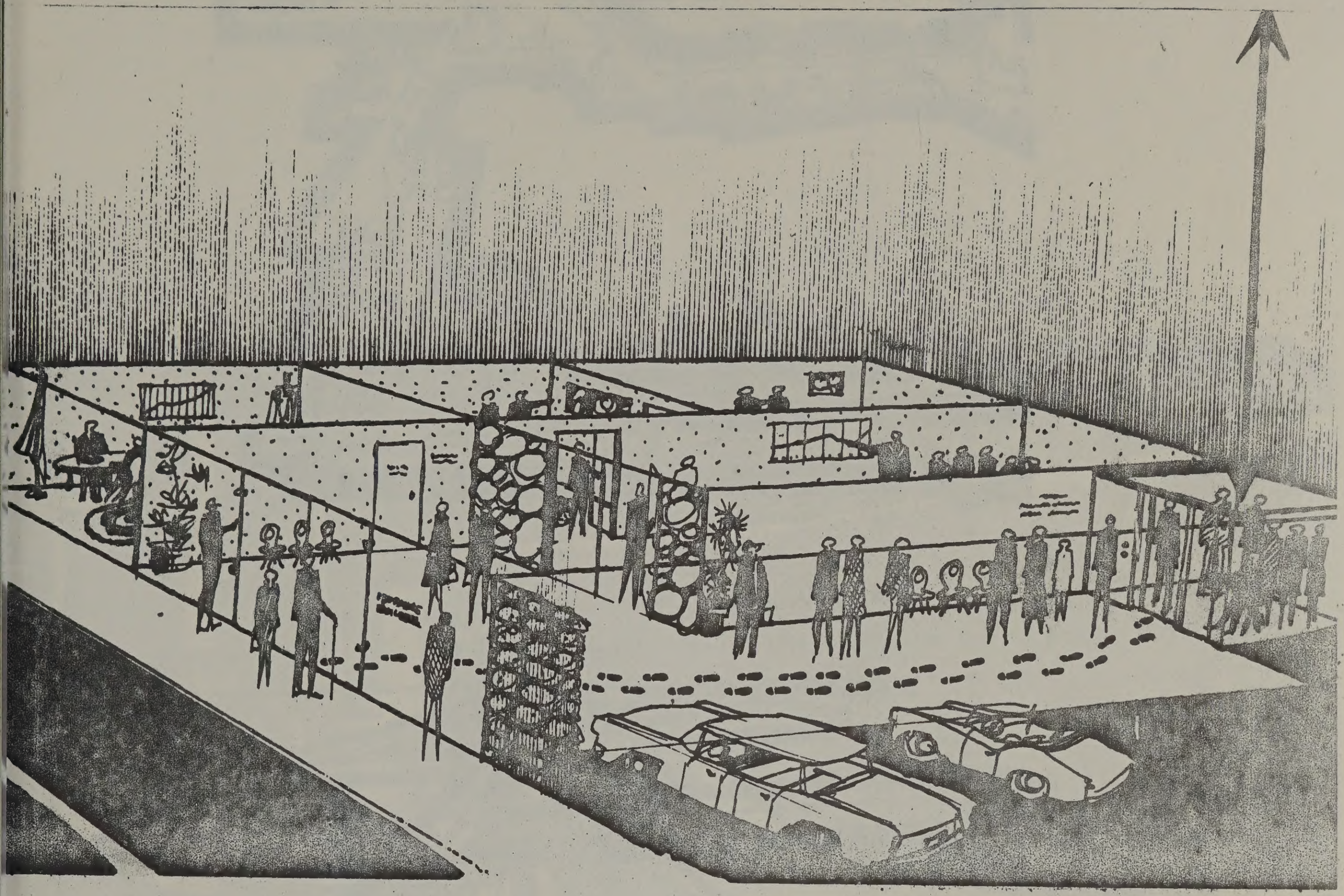


Fig. III. 7

The city wage earner passes through the plaza and enters a series of lobby rooms, enters a small cubicle called an elevator which shoots him up a man-made tube to his tenth floor office, all the while being rushed, pushed and directed through a series of right-angled rooms and corridors created by man.

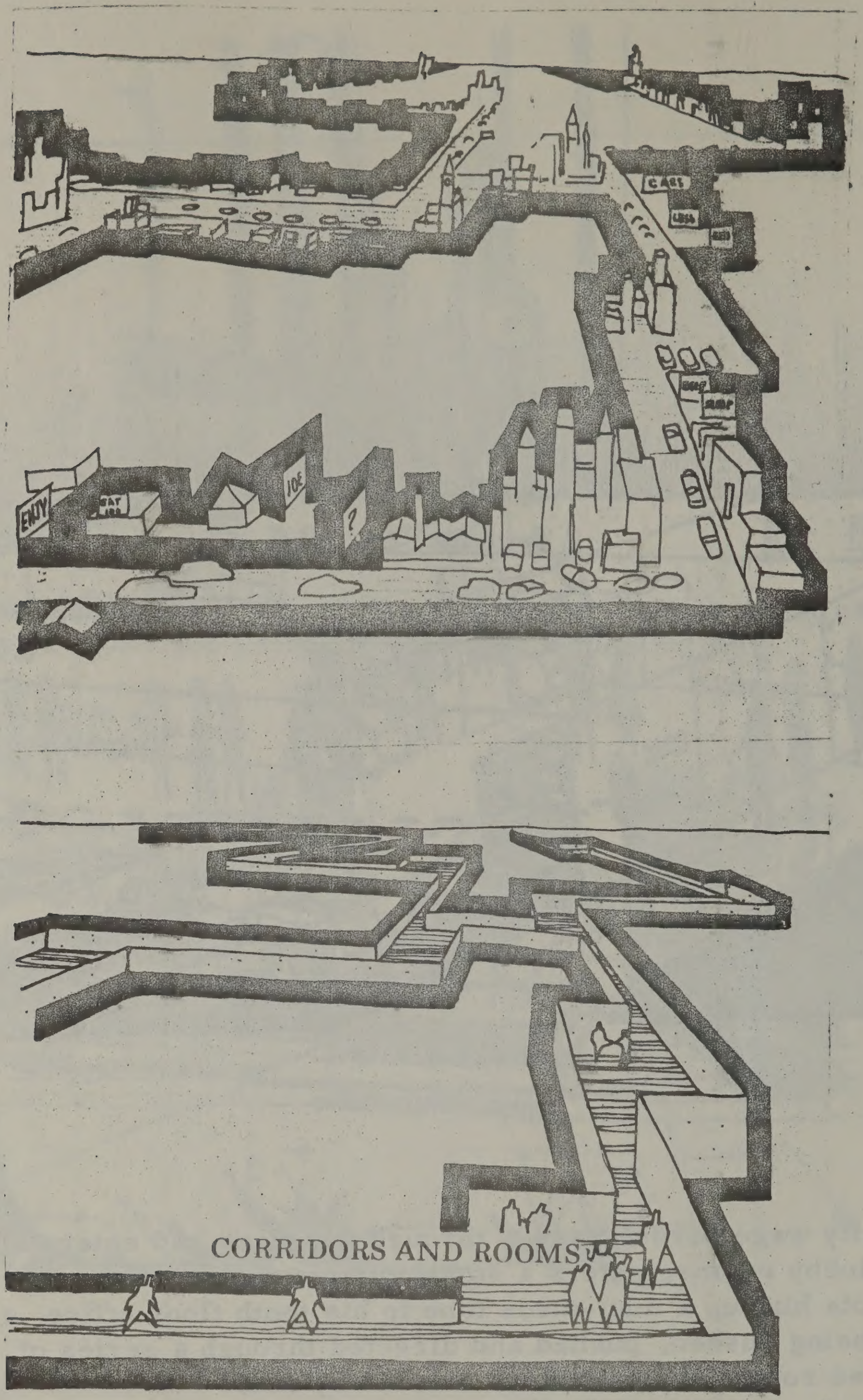


Fig. III. 8

In the evening it's the same type of experience. He is being channeled through a series of rooms and corridors including the highway street corridor directing him through the urban fabric.

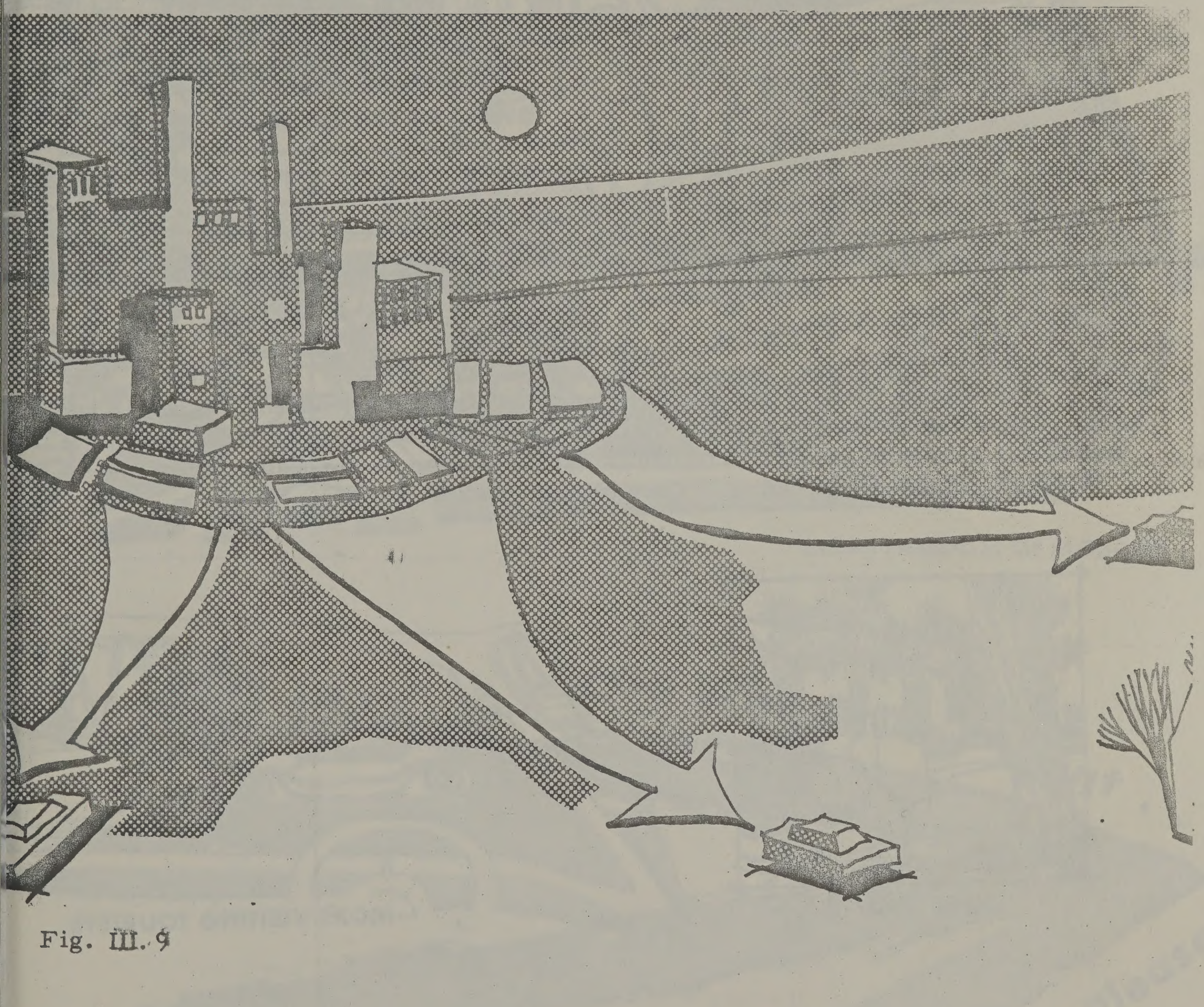


Fig. III. 9

After spending his working days in this bumper-to-bumper, wall-to-wall, straight line and right angled world, the urbanite seeks escape to the countryside and the public lands.

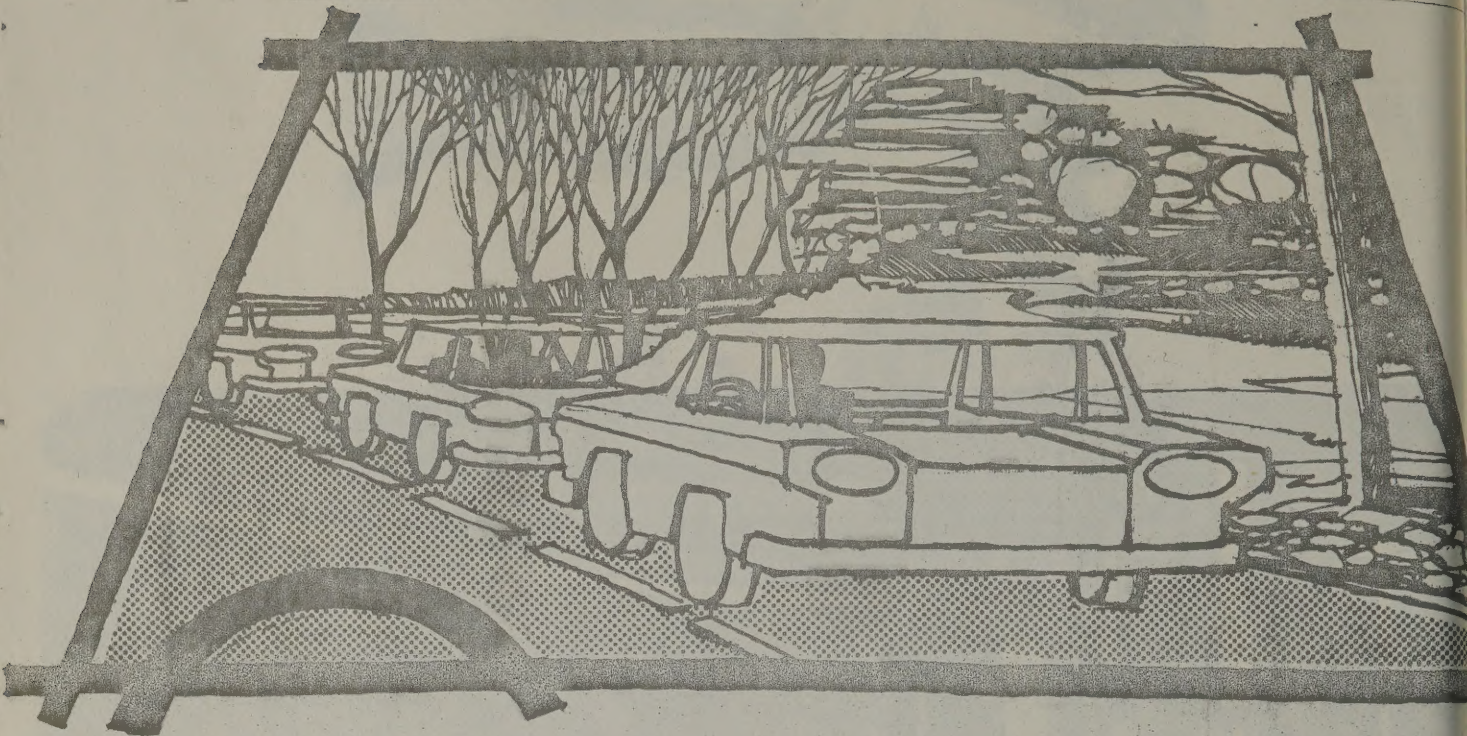


Fig. III.10

He leaves the city and heads for the natural environment. What is he really seeking? Economists predict that city dwellers will head for the places of natural beauty because the future urbanite will be better educated and have a higher standard of living. That in turn implies . . . .

Fig. III.11

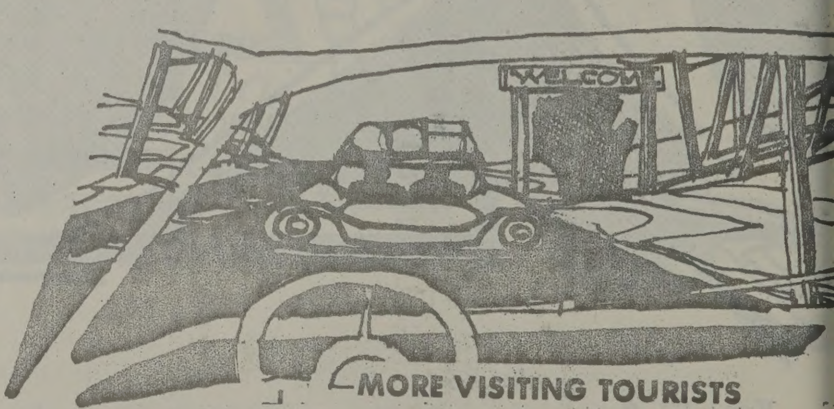
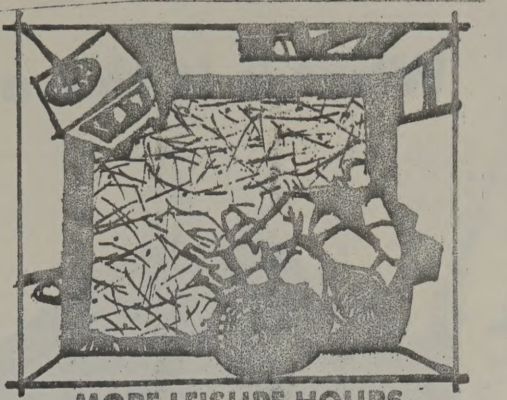
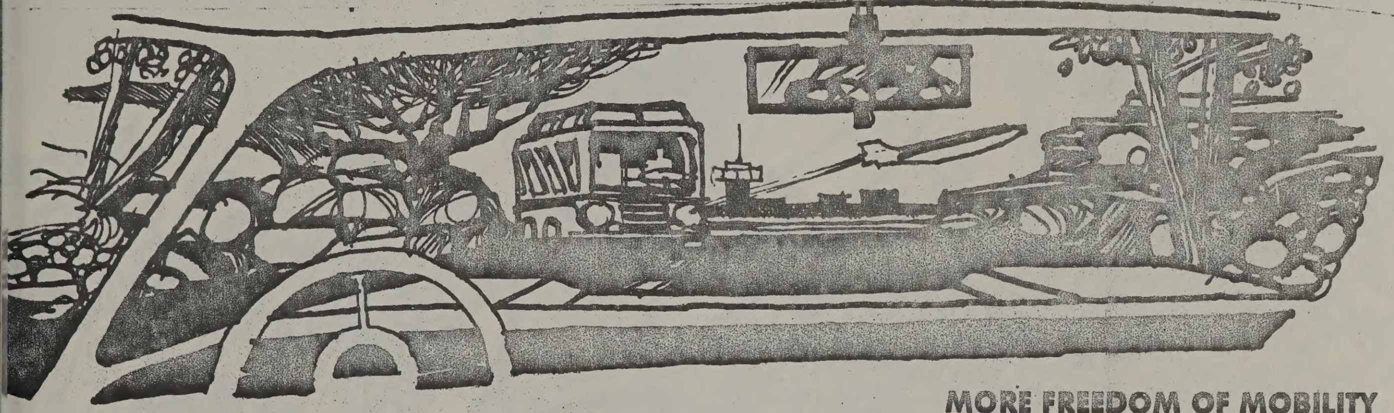


Fig. III.12

WHO HAVE—MORE MONEY TO SPEND



MORE LEISURE HOURS



MORE FREEDOM OF MOBILITY

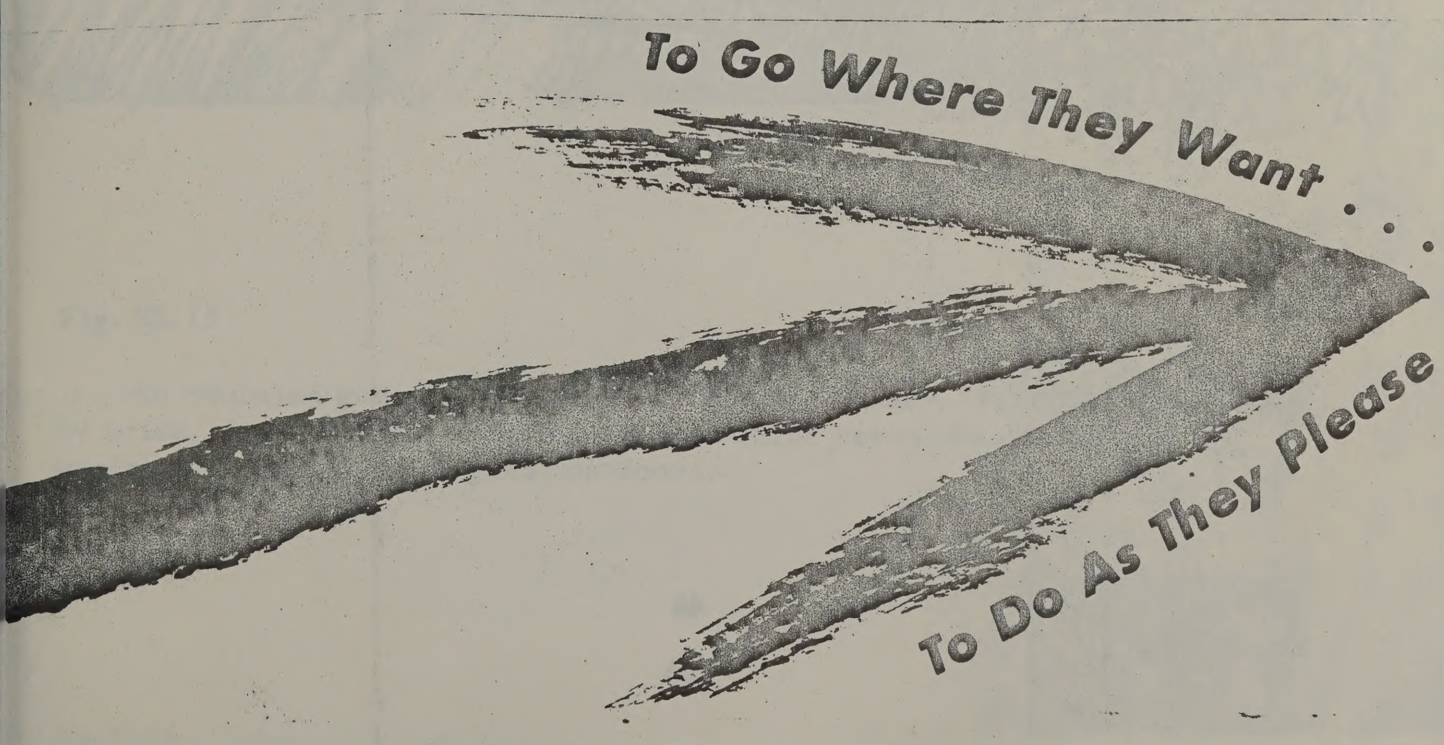

To Go Where They Want . . .
To Do As They Please

Fig. III 13

What is it these people really seek seek seek?

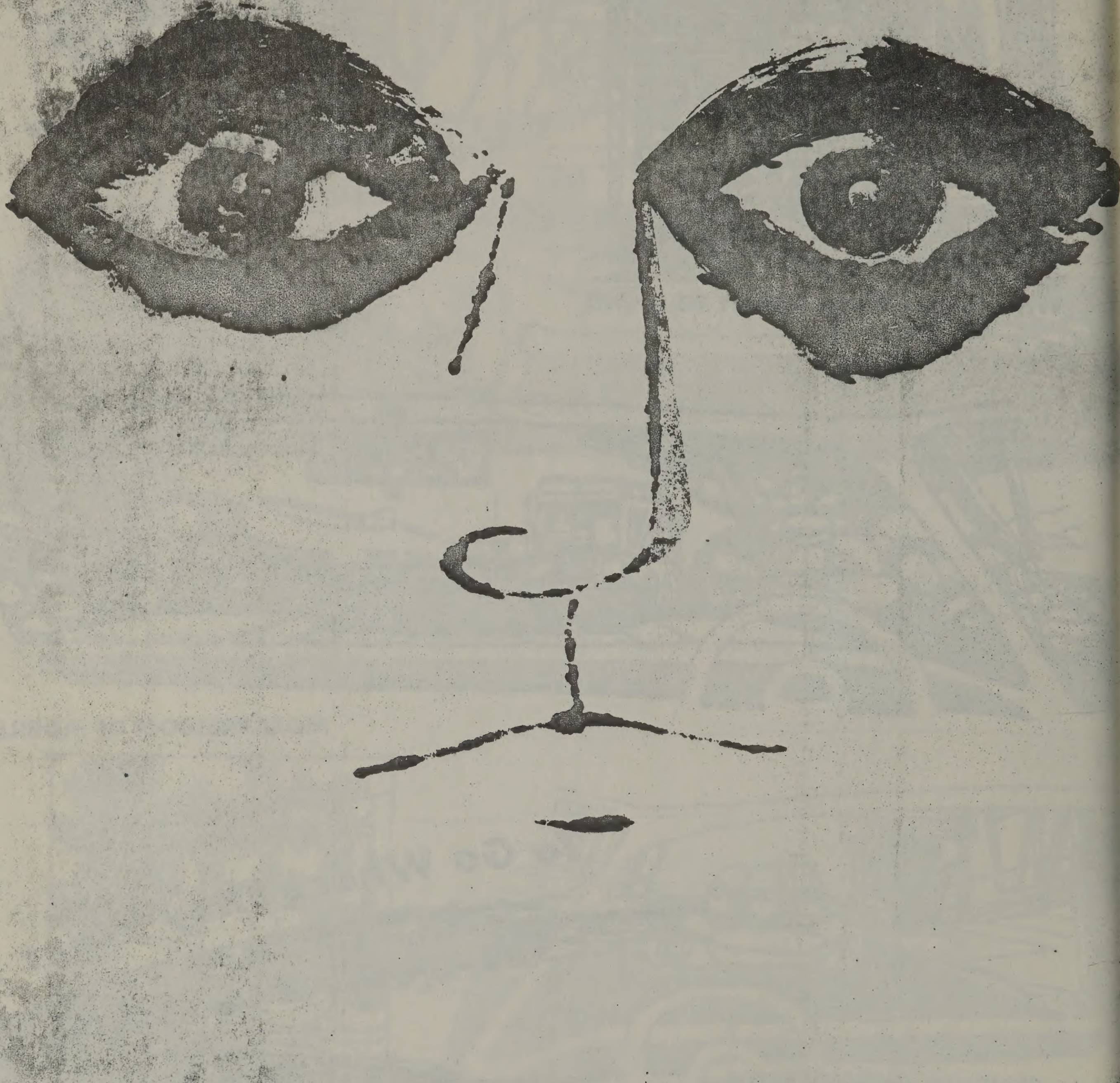


Fig. III. 14

Fig. III. 15

An educated guess would suggest that the urbanite, surrounded by brick, steel, glass, asphalt, and wirescape seeks the change and variety that exists in the great outdoors.

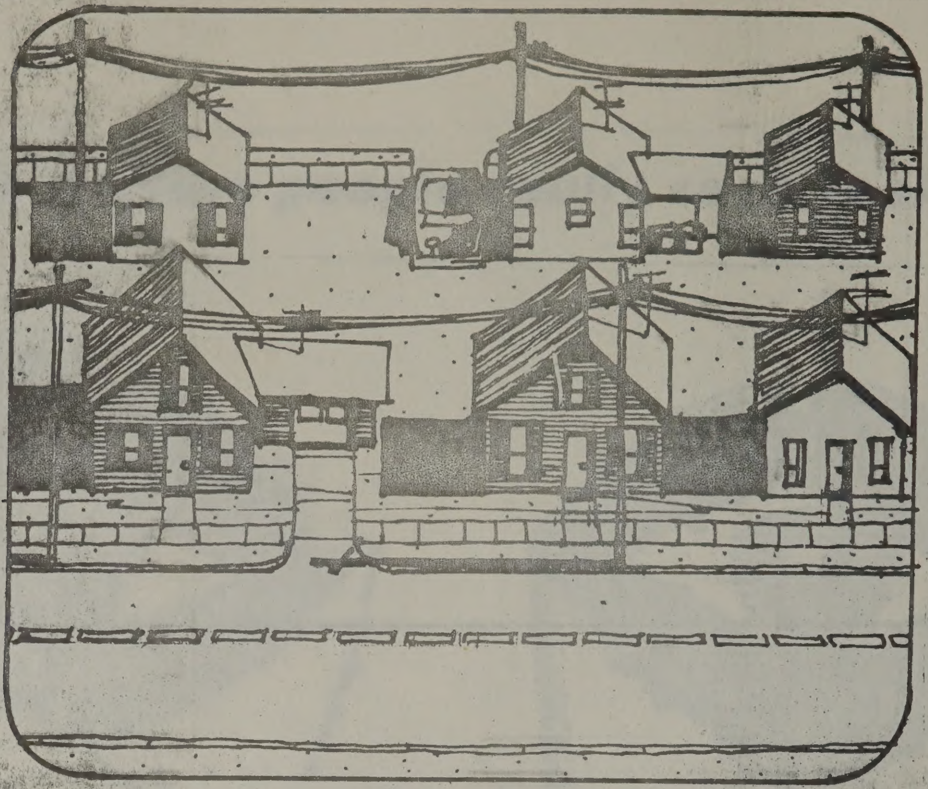


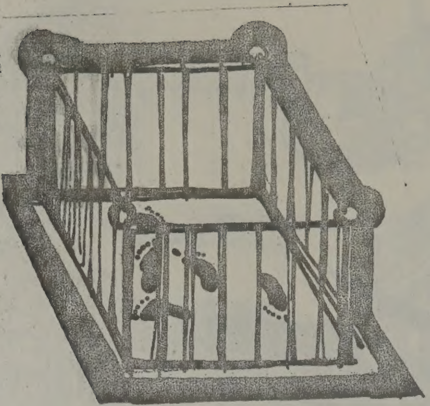
Fig. III. 16

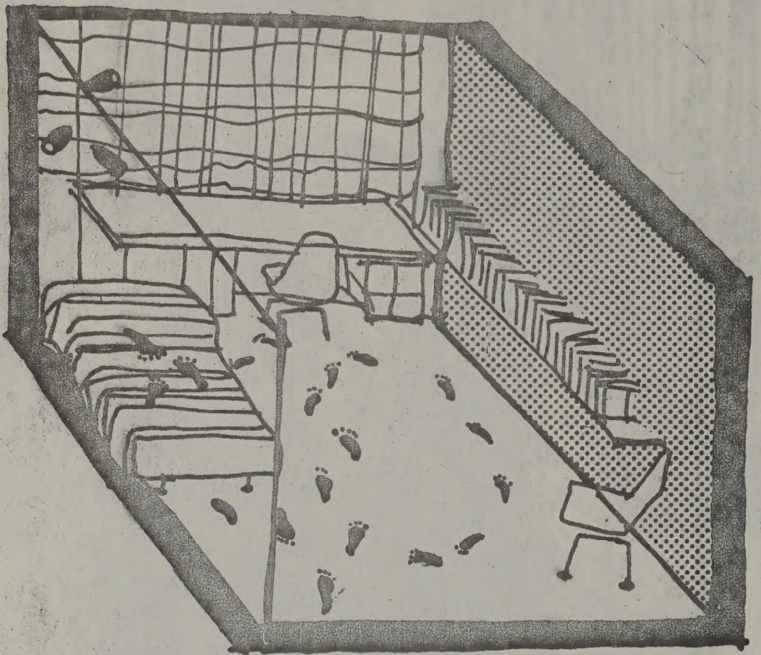
But in the public land systems, the urbanites' tents are to be found pitched tent-peg to tent-peg and complete with portable TV sets, the smell or burning steak and all the conveniences of home. Nevertheless, he can lift up his tent flap and see and smell the timber on a nearby hillside; he can also hear the wildlife it supports. He shares the friendship of new neighbors and can discover a change and variety from that which he left behind.

Fig. III. 17

Fig. III. 18

The farmer, on the other hand, might like change and variety from the rural scene, the natural scene, and the rows upon rows of corn. He no doubt would like the complex enchantment and excitement of the city.





Man has always sought change and variety in his search for life.

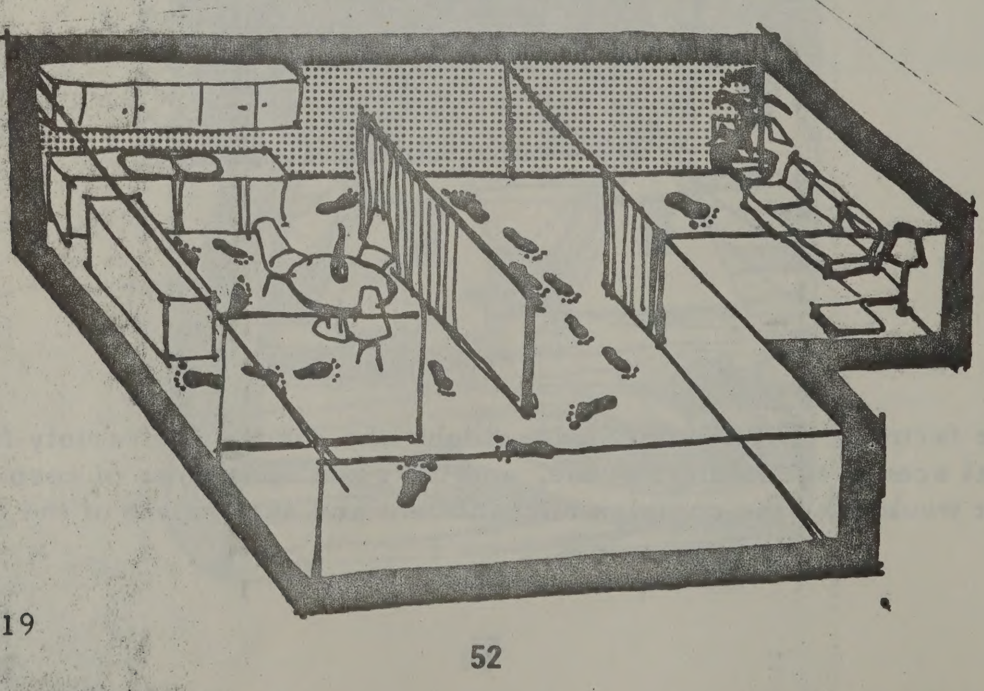


Fig. III. 19

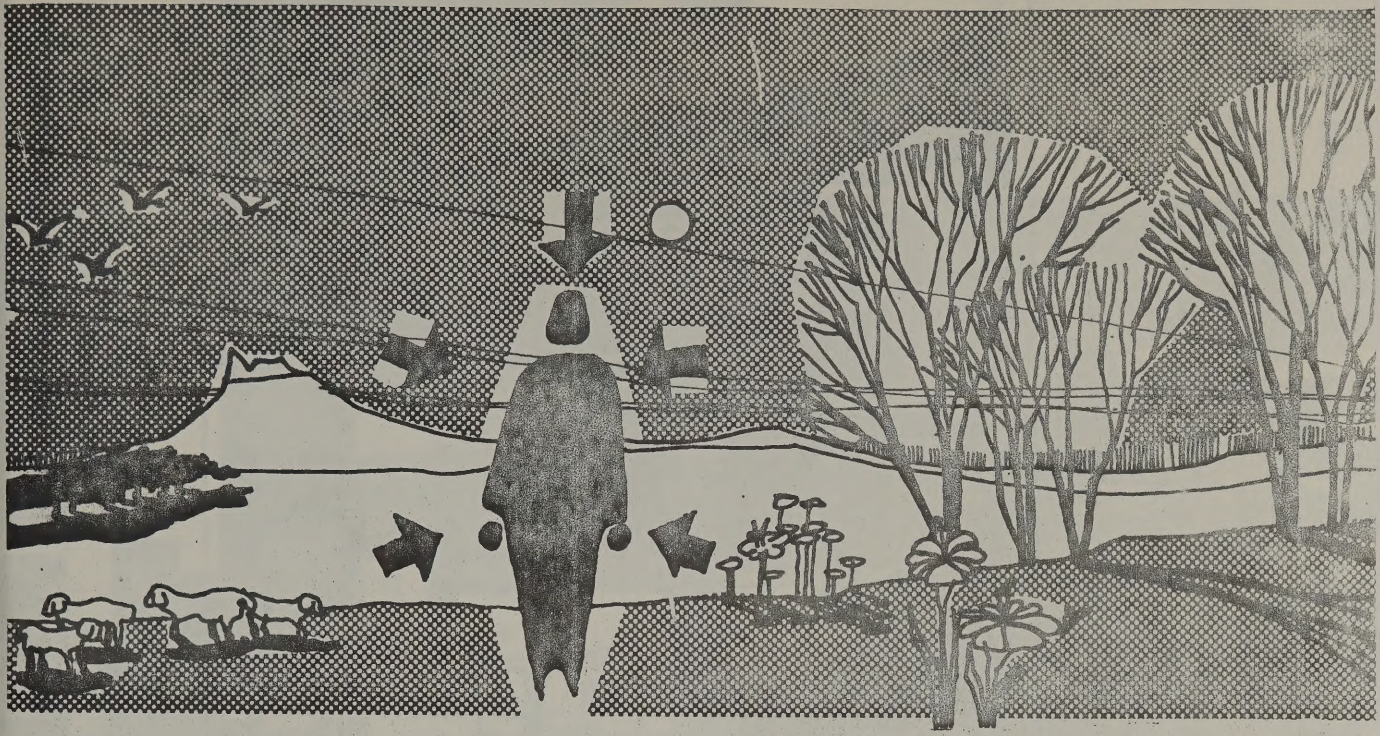


Fig. III. 20

In the December 22, 1961, issue of LIFE magazine, Joseph Wood Krutch, educator, biographer, and naturalist-philosopher, touched on the meaning of this great search for change, and variety in the rural-regional landscape when he wrote:

> "We need some contact with the thing we sprang from. We need Nature at least as a part of the context of our lives . . . Without Nature, without wilderness even, we are compelled to renounce an important part of our heritage . . . On some summer vacation or some country weekend we realize that what we are experiencing is more than merely a relief from the pressures of city life; that we have not merely escaped from something but have also entered into something; that we have joined the greatest of all communities, which is not that of men alone but of everything which shares, with man, the great adventure of being alive."

This something, then, this great out-there, made up of intrinsic and extrinsic values, becomes in many minds an essential factor for well being and happiness.

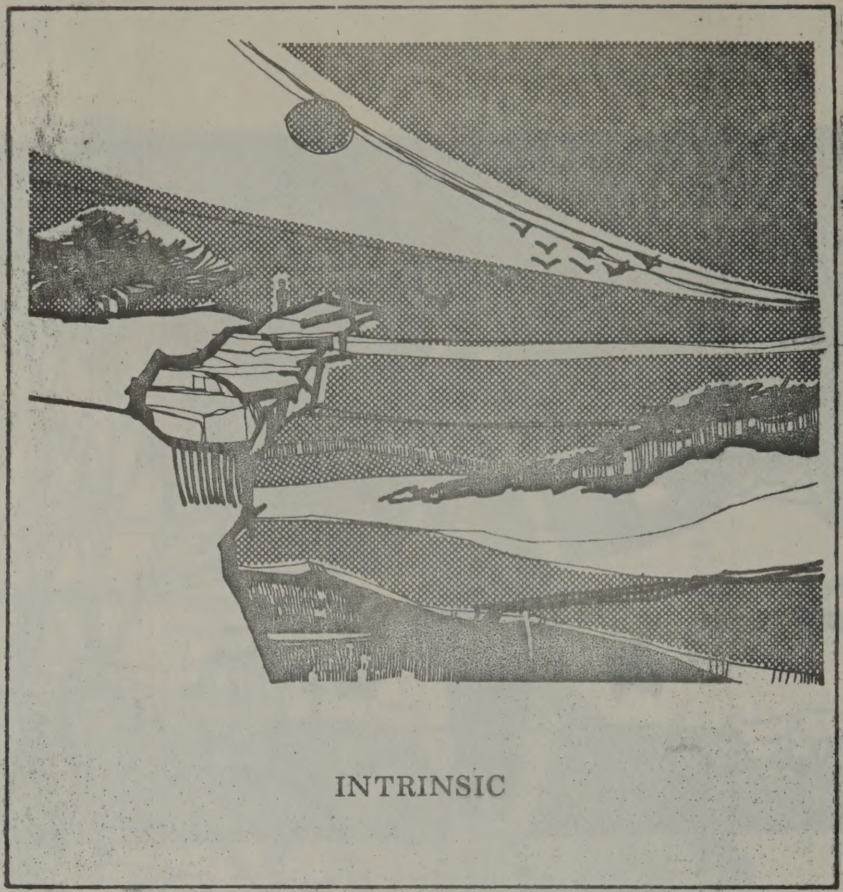


Fig. III. 21

The landscapes can be divided into intrinsic values which are resources in the native state and extrinsic values that have been created by man-made changes, adaptions and additions to the natural resources.

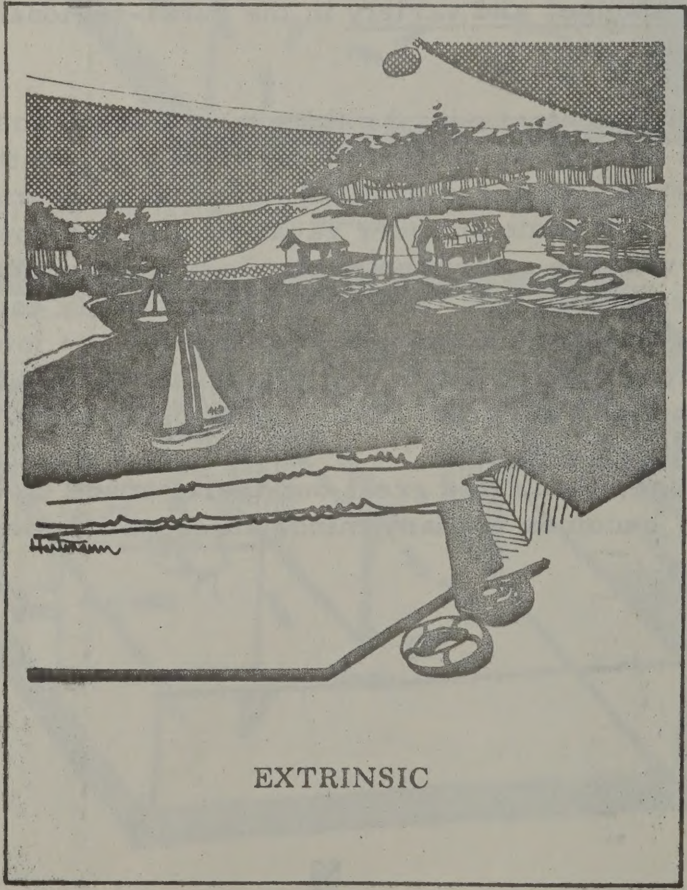


Fig. III. 22

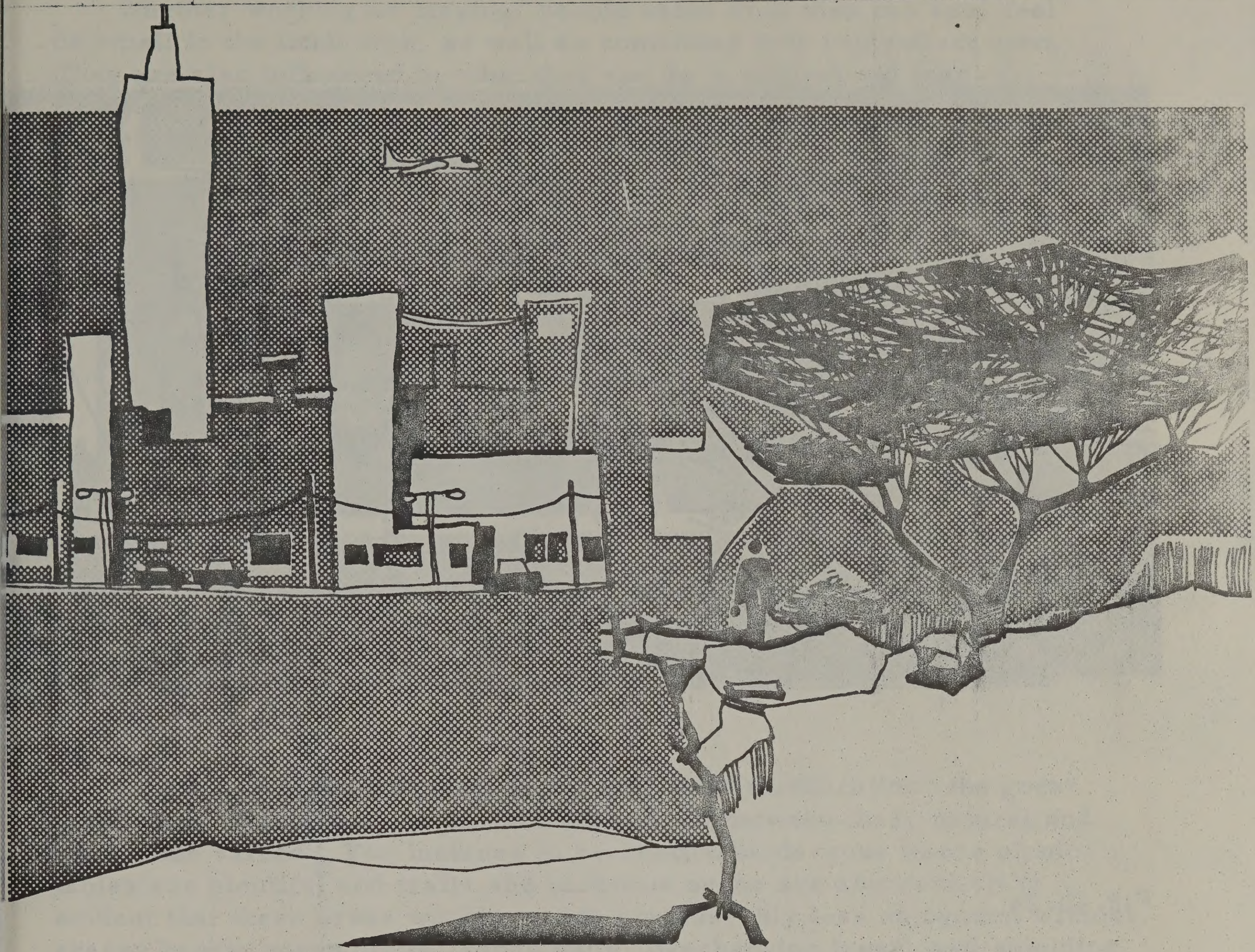


Fig. III. 23

Exploding populations, greater mechanization, and urban sprawl have resulted in the expansion of mediocre man-made facilities in too many places where natural values have been sacrificed for expeditious development. Scores of city dwellers appreciate the stimulus of crowds, bright lights, abundance of stores, services and the sophistication of city entertainment. However, many now and then feel the need for a change; for a kind of vision and perspective that most of our inner cities do not as yet provide.

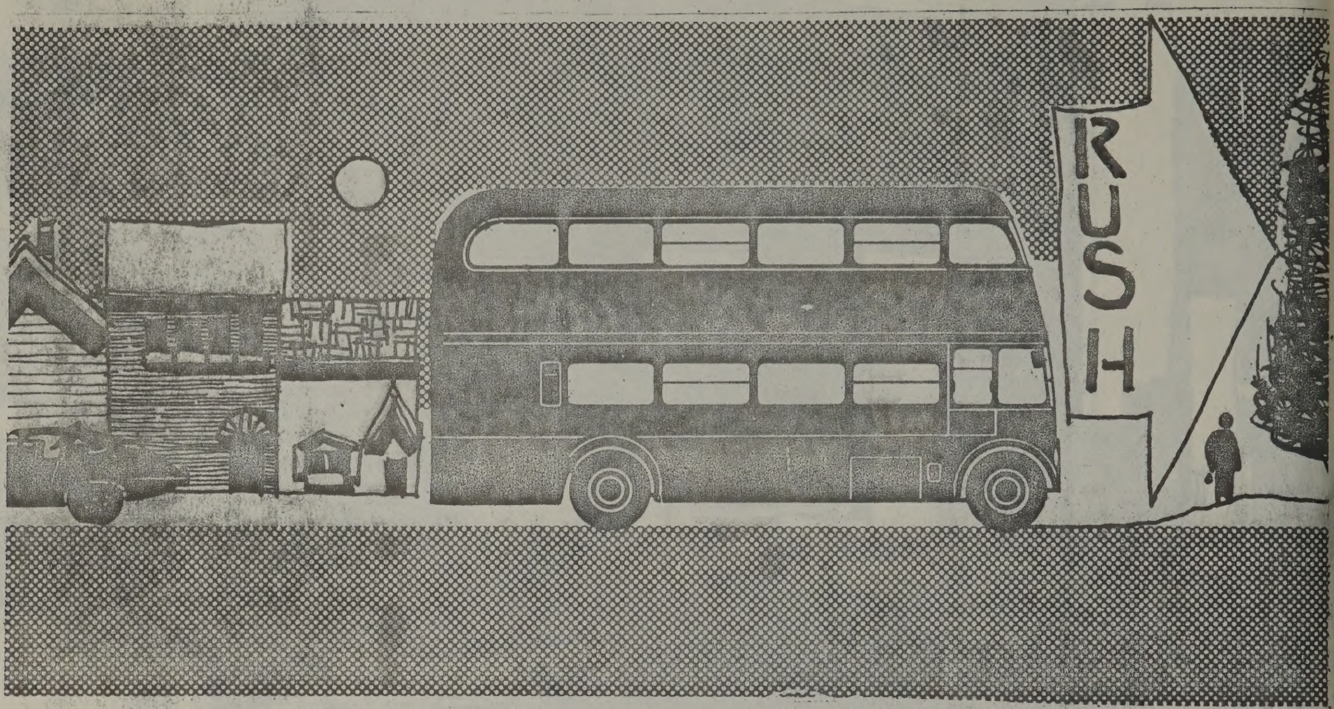


Fig. III. 24

The modern-day rush to ensure food, shelter, transportation, and play for as many people as possible, has overemphasized providing extrinsic values only (and often badly designed ones) at the expense of intrinsic values. Both the intrinsic and well-designed extrinsic resources are important in order to envoke full enjoyment of the total landscape.

Whether working or playing, people value what they can see, feel or smell in the landscape, as well as something they can reflect upon. They are also influenced by what they can do in natural and man-modified terrains. One type recreates the mind and the other, supported by well designed facilities, rebuilds or serves the body.

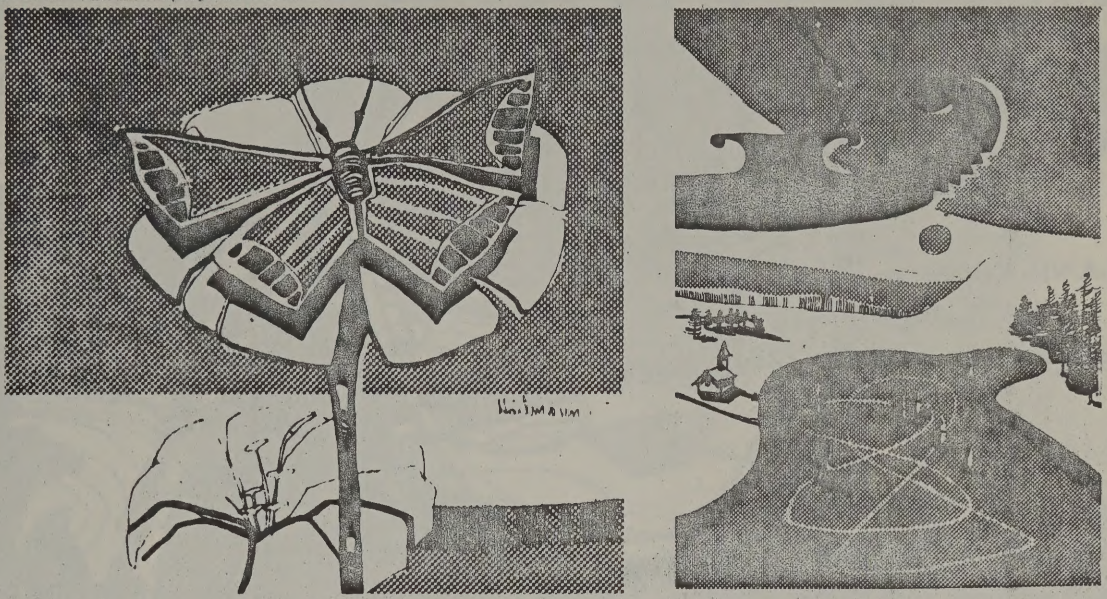


Fig. III. 25

In this age of natural landscape "use" and "modification" the great task is one of achieving balanced development between these natural and man-made values. For instance in recreation landscapes where picnic tables are plentiful and trails and barbecue ovens are abundant, it is evident that these areas would provide considerably less enjoyment without grassy banks, steep bluffs, sandy spits, overhanging trees, and shielding shrubs that screen traffic and other types of encroachments that accompany civilization.

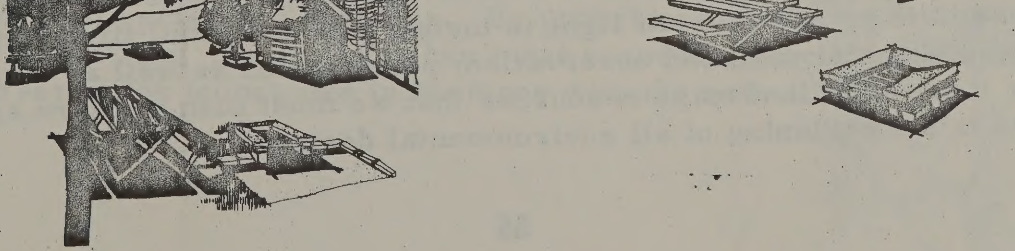


Fig. III. 26

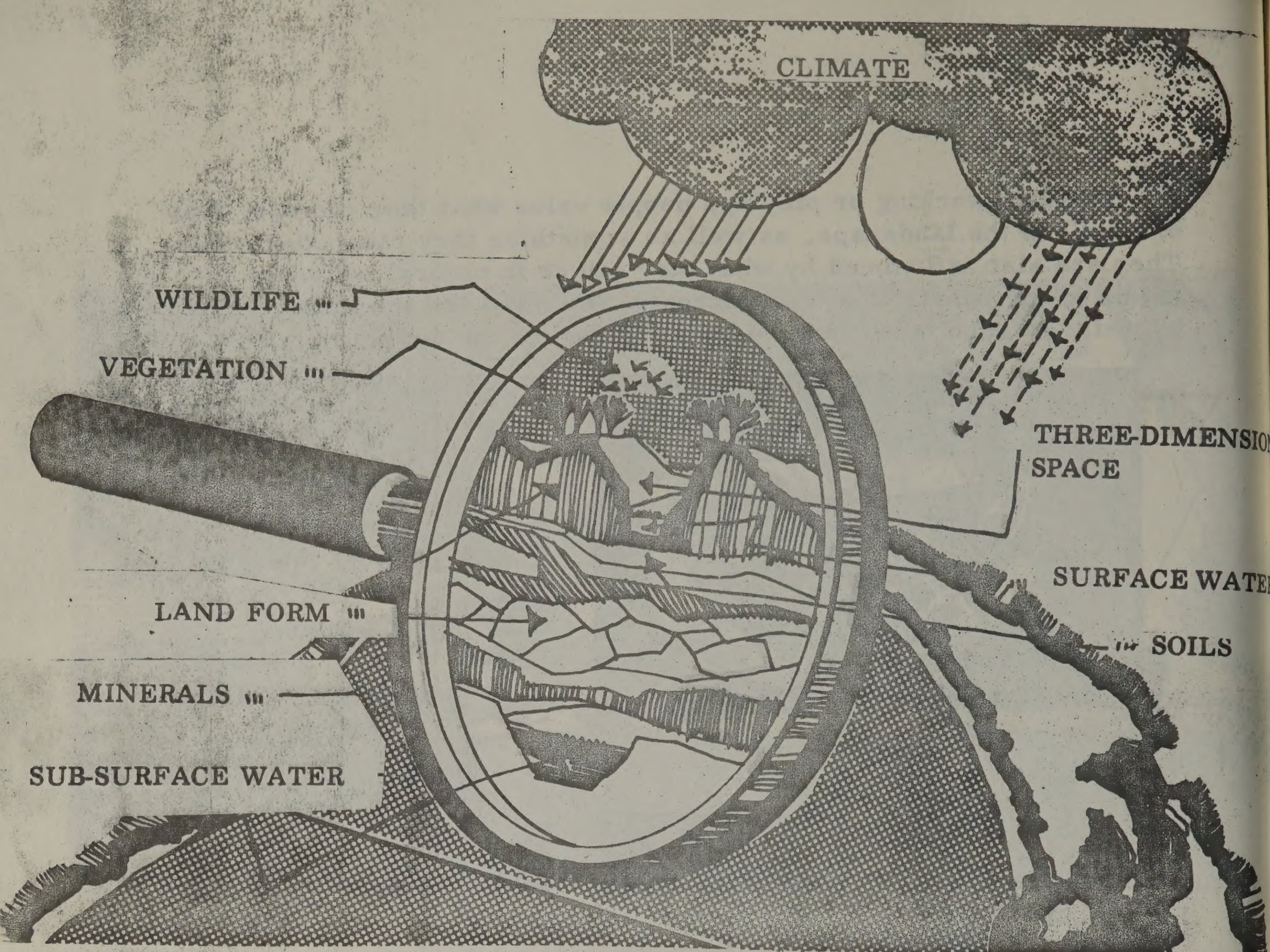


Fig. III.27

This task of creating balanced development depends upon a greater awareness of the quality landscape resources by everyone. In an editorial entitled "Getting Under Nature's Skin," (Landscape Architecture, 1963), editor Grady Clay wrote:

> "The man who seeks to understand Nature needs to get beneath its surface; he must see it and see through it; he must look, and admit that looking is not enough. He must weight it without a hoist, measure it with ancient yardsticks, while always seeking something better for the job . . . The artist who sketches a scene knows more about the landscape than when he first cast eyes upon it; the sculptor can tell us of qualities in wood and stone no eye alone can see . . . Merely looking at nature is seldom enough for those who hope to enjoy it, and this act is hardly more than a start for those who intend to change it . . . If one is to progress from sight to insight, the essential first step is painstaking and repeated observation; perspiration as well as inspiration. For it is to the landscape resources that we must turn and turn again; here is the beginning of all environmental design."

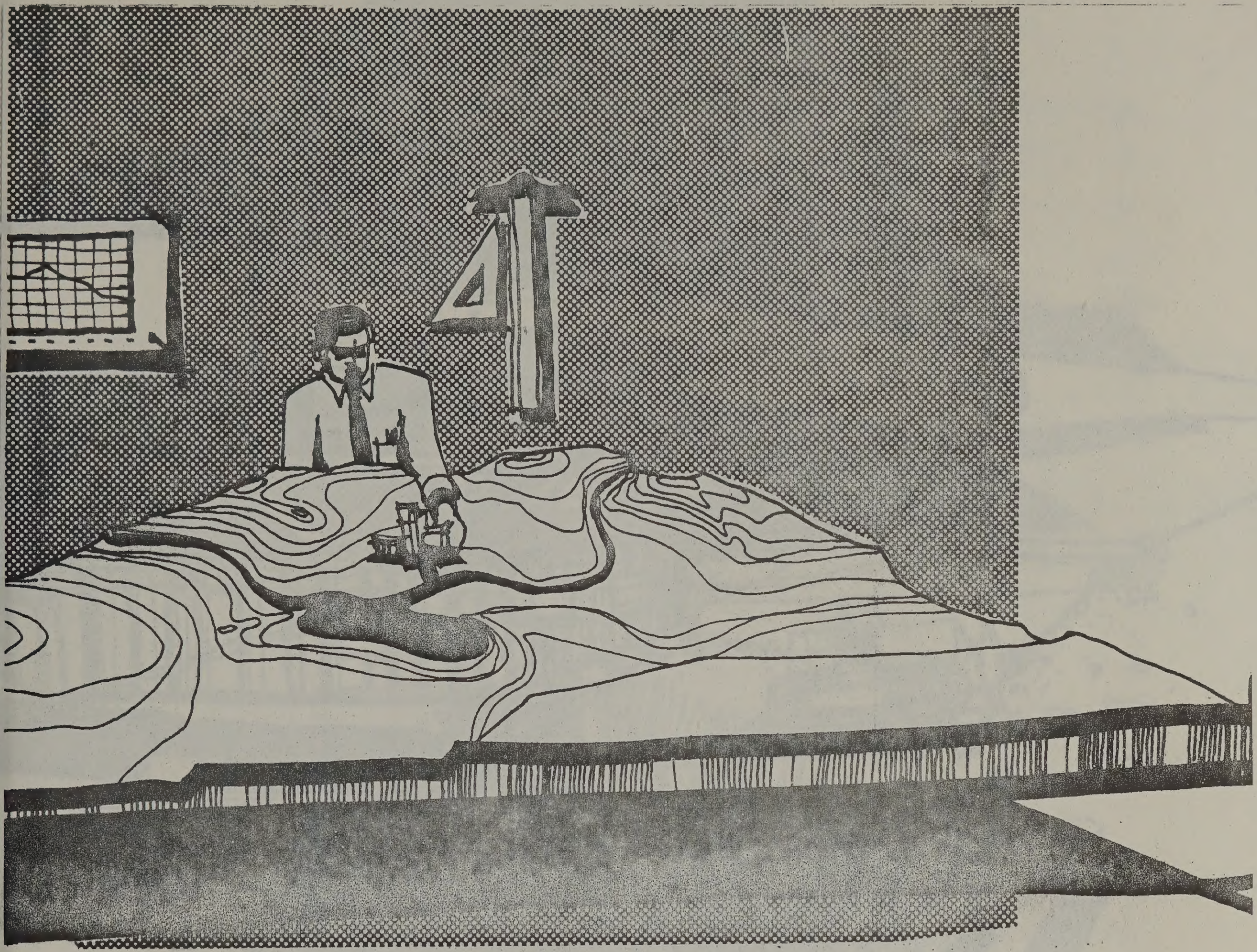


Fig. III. 28

A fully integrated understanding of the landscape resources on public lands can demonstrate the alternative uses of the area without destroying basic scientific qualities. By understanding the 'carrying capacity' of the site, the designer can most assuredly place his environmental creation for human use in harmony with the scientific values.

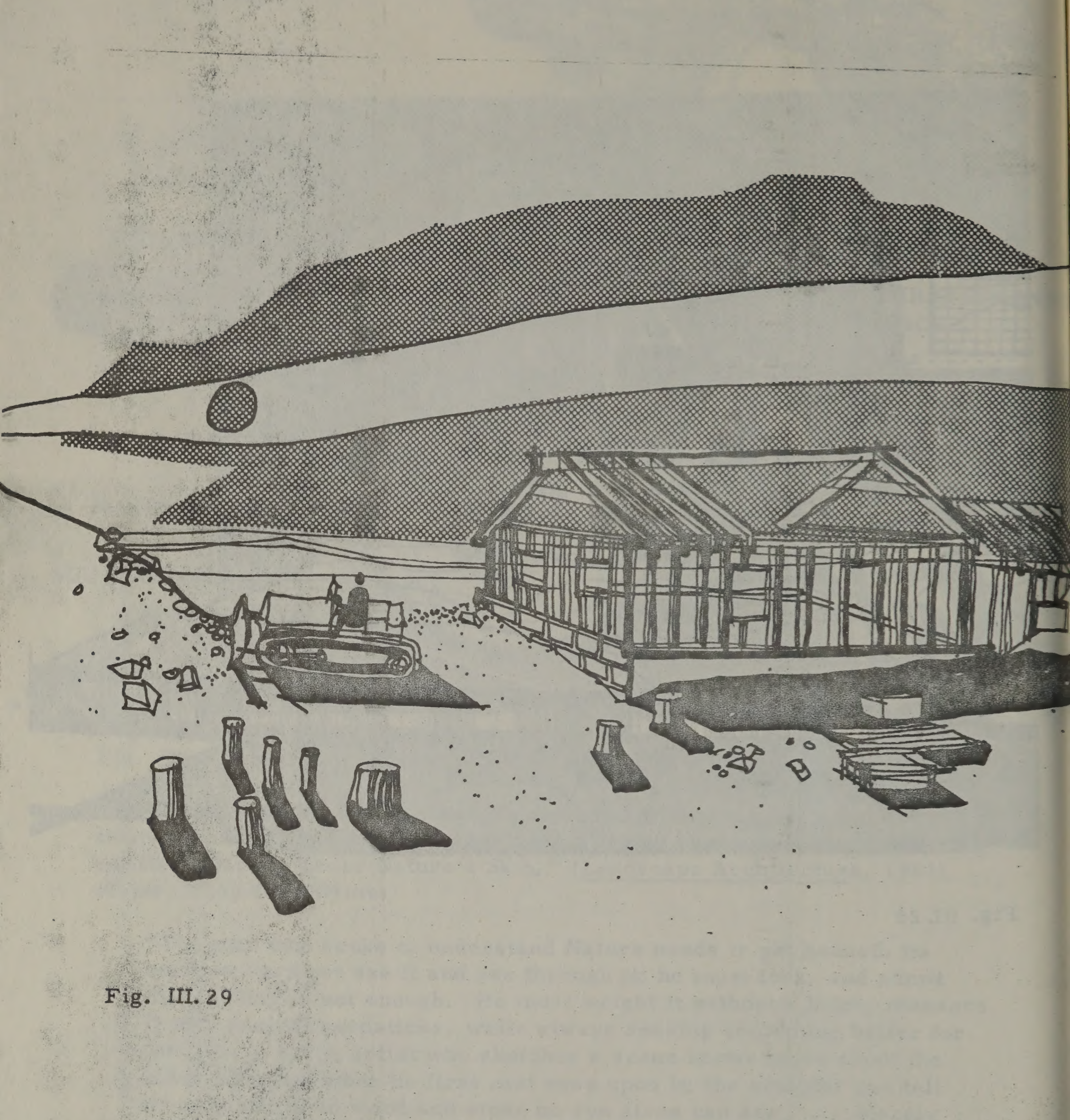


Fig. III. 29

Without such knowledge he may well destroy the very values that attracted him to the site in the first place.

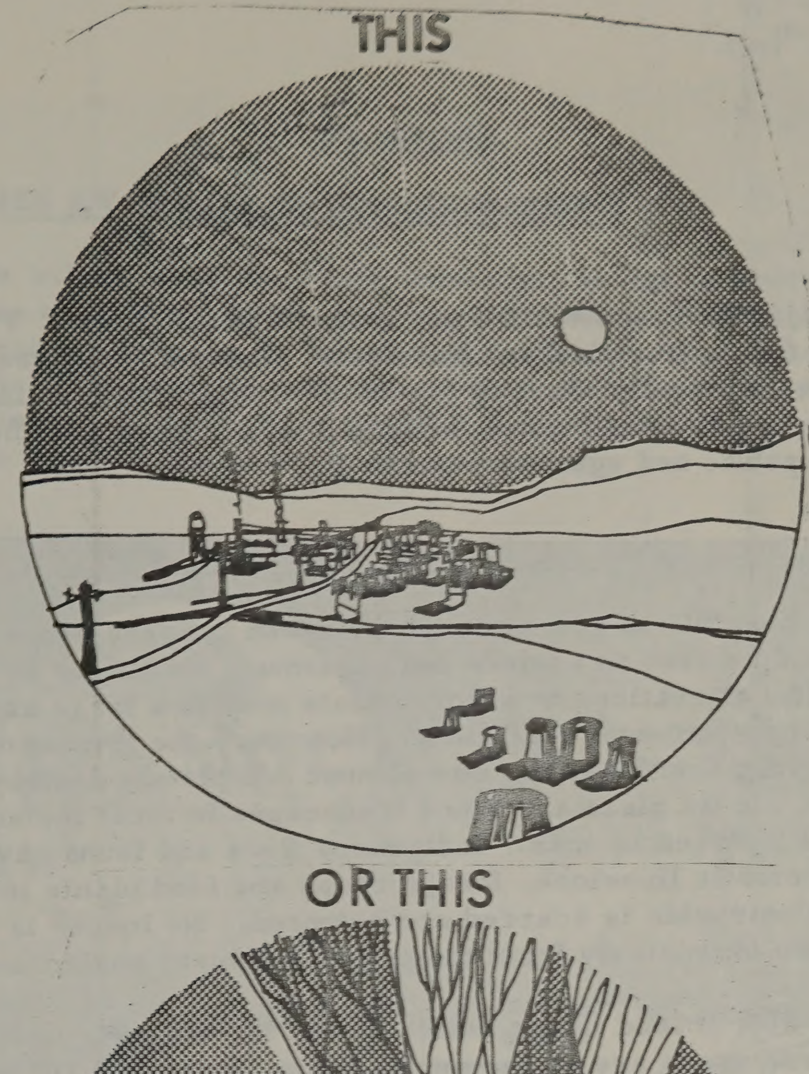


Fig. III. 30

There is a growing awareness by designers, developers and public lands managers that these integrated scientific values must be understood and protected if there is to be a healthy natural landscape for the future.

Chapter IV

ENVIRONMENTAL QUALITY

Three major environmental types exist on public lands. First are the relatively few undisturbed natural areas. Second are those areas that have been drastically changed (surface mining, overgrazing, dams and flowages, cutover and burned forests, etc.). Third are those lands under careful public and agency stewardship.

MANS' INFLUENCE UPON HIS NATURAL ENVIRONMENTAL BASE

If it were possible to step back six or seven hundred years, present knowledge could be used to achieve near optimum conditions by making a series of careful alterations to accommodate man in a large array of near-perfect environmental conditions. However, the impact of man upon the American Continent has now almost completely destroyed the virgin country. In its place are found landscapes in most instances dramatically influenced by man. Indigenous flora and fauna have been replaced by domestic livestock, forage crops and food plants in many areas. The countryside is scarred and battered. No longer is it possible to draw extensively from the original natural environmental base.

Less than 20% of land in the United States is relatively unscathed. The bulk of these areas are on the public lands, most of them in Alaska.

When considering environmental quality on public lands there should be concern not only with preservation of existing excellent natural areas but also for improvement of areas already under intensive management. Natural values should be recreated, where possible, on lands where they have been drastically changed.

Obviously, not all of the public lands have the same potential for maximizing environmental quality. However, all lands do have a capability to support a distinctive ecological community and should be treated with respect. The systems of inventories and corridor delineation described in these reports can identify those portions of the public lands that have the highest potential for maintaining maximum environmental values. This is the first important step in preserving the few remaining natural acres and restoring those areas that have been devastated.

MAN BECOMES AWARE OF HIS ENVIRONMENT

The '60's will no doubt be remembered as the age of environmental awareness, an age when man became aware of the real threats to his life support system created by decades of destructive and wasteful land uses. For the first time, he has had an opportunity to look down from space and compare the vitality of the life giving planet earth with what appears to be the lifeless environment of the moon.

Fig. IV.1

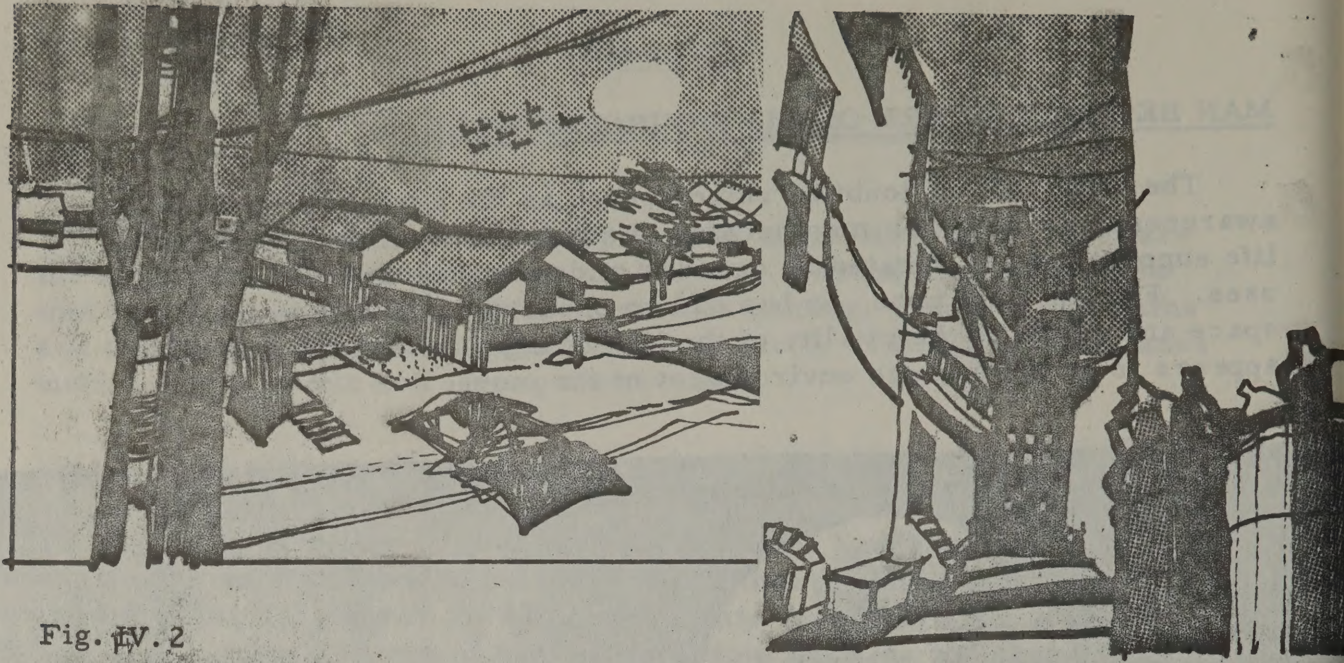


Fig. IV.2

His mobility on earth combined with an ever increasing availability of communication devices has permitted him to perceive various environmental situations around the globe. In perceiving, man has compared. He has looked for the difference between things and has whetted his discriminatory powers.

He has had an opportunity to compare the ghettos of the city with suburban neighborhoods. He has compared the super highways with the parkways, above-ground utilities and buried utilities, protection of productive farmlands and wasteful development. He has seen crystal clear streams and polluted ones, breathed clean air and polluted air, witnessed the blessing of peace and the horrors of war, peaceful demonstrations and riots in the streets.

ENVIRONMENTAL OPTIONS

Man has seen and he has compared an almost overwhelming series of environmental happenings, and he has become aware of an expanding number of environmental options.

Within the past few years, there have been a growing number of efforts to record these many environmental differences and to evaluate such diversity. Is it good, bad or mediocre? Can "points", rather than dollar value be placed on various natural and human attitudes toward environmental circumstances?

Is it possible to recognize the difference between human desires that can be recorded and measured and basic human needs for survival that can be analyzed only through increased efforts by physiologists, psychologists and doctors in the field of preventive medicine? Can multi-disciplinary efforts be focused on these tasks in place of the isolated, single-purpose judgment? Can inter-agency cooperation be encouraged to assure wise land use decisions? Can resource data be recorded and organized by remote sensing and computer graphics?

Scholarly effort in all of these areas took place in the late 1960's, and today the beginning of the 1970's offers a growing choice of answers to many environmental questions. It must also be quickly pointed out, however, that the answers and the programs now in existence and to be created to answer such questions are at the moment in varying degrees of refinement.

RESOURCE INVENTORY TECHNIQUES

Resource inventory techniques applicable to the public lands have already been worked out for studies done in Wisconsin, the Upper Mississippi Basin, the Great Lakes Basin, and Alaska (see Appendix E). Work is also underway to conduct detailed ecological surveys via new remote sensing and commuter devices being developed by the National Aeronautic Space Administration. Research on the use of such equipment for environmental studies is being funded by NASA in the Environmental Awareness Center at the University of Wisconsin, Madison.

By applying the first technique (resource inventory studies) it would be possible in a rapid, first approximation way, to inventory vast patterns of environmental diversity offering many options for the future. Such studies would also show where this diversity is subject to near future obliteration. Once such areas are identified, more refined sensing and data bank systems costing more and calling for a higher degree of talent could be applied in priority areas.

Given the seriousness of environmental degradation, it appears essential that there should be experimentation by persons who have environmental expertise at various scales with all recognized techniques.

Action Based on "Subjective" Judgments Needed Now

A major premise of these reports is that the nation cannot afford to wait until precise scientific measurements of what is "good" and "bad" environment is learned through basic physiological and psychological research. Financial and moral support for both basic and applied research in the critical environmental area must be increased. At the same time, action must proceed with the best "subjective" judgment of environmental quality that is available at this point in history.

At the same time, it must be recognized that if environmental quality is accepted as highly subjective in the early '70's, an integrated, professional-lay judgment of environmental quality is called for until more precise measurement is possible.

BASIC ENVIRONMENTAL INGREDIENTS

Environmental quality depends upon the degree to which the individual consciously and unconsciously understands his basic requirements for (1) survival and (2) well-being and happiness.

Survival: The Need for Clean Air

The professional scientist recognizes that 2,000 particles of pollution in a section of air half the size of a sugar cube reduces the environmental quality of pure air.

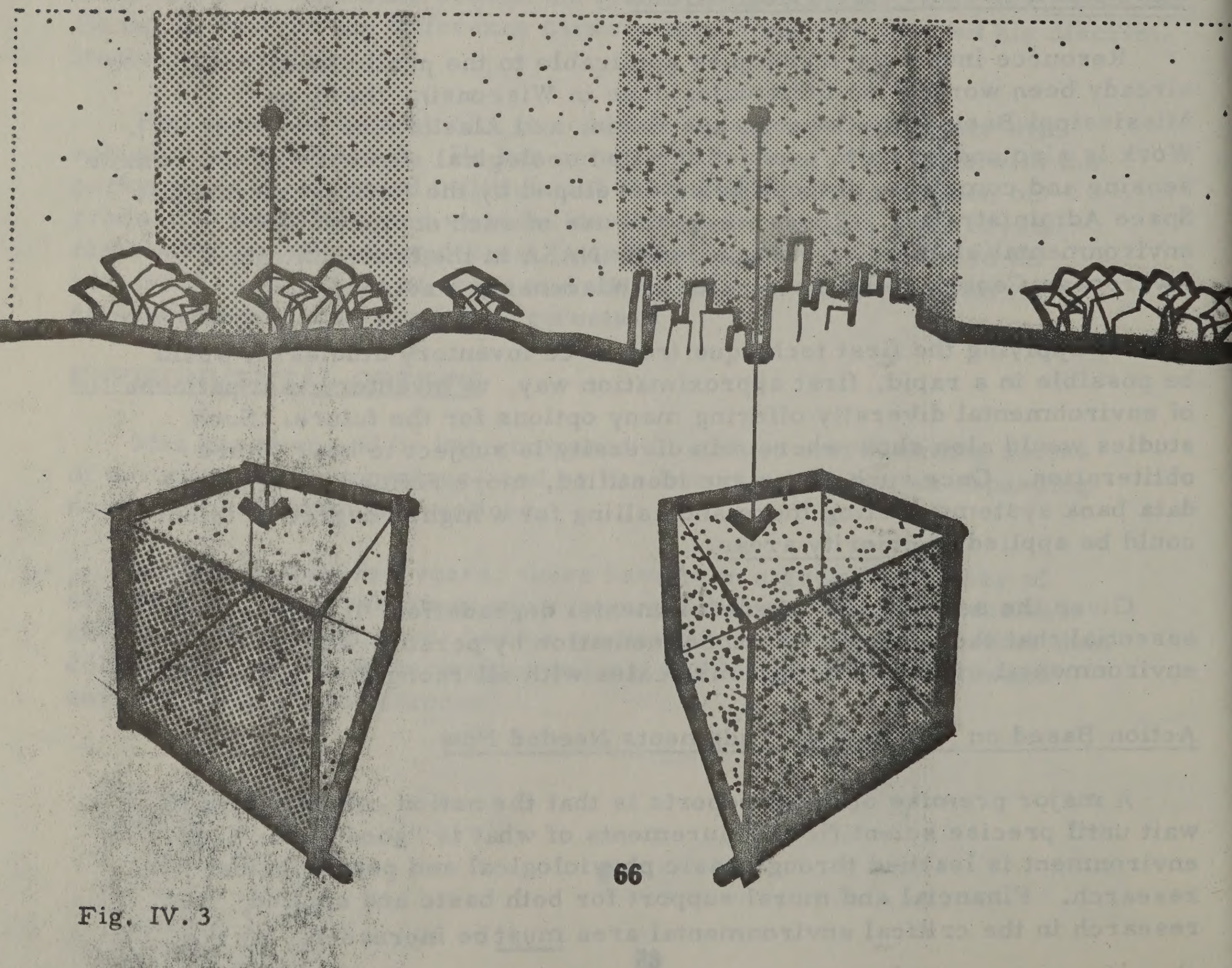


Fig. IV. 3

On the other hand, it may require the injection of 15,000 particles found in most metropolitan areas today, and two million human coughs before the lay public recognizes a reduction in environmental quality.

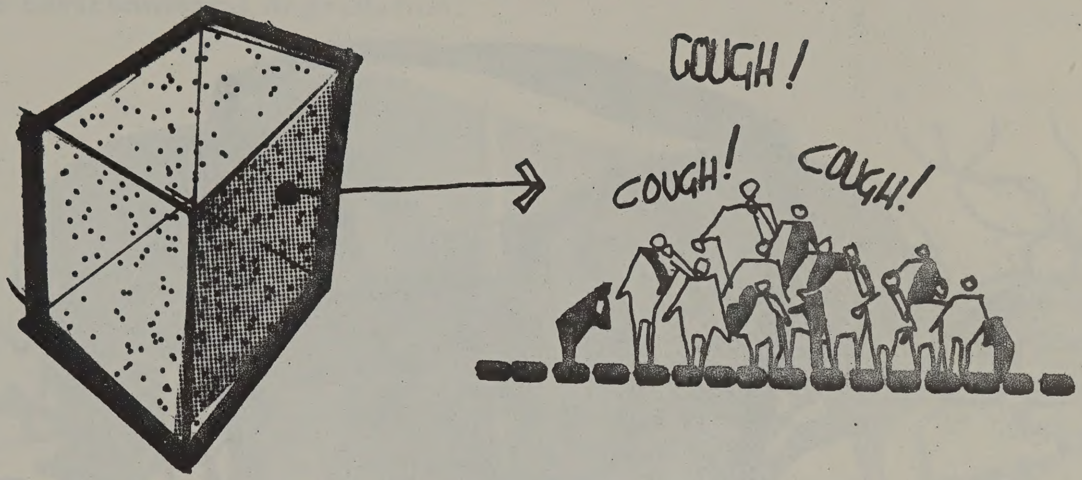

COUGH!
COUGH!
COUGH!

Fig. IV.4

A different evaluation of air quality could be developed if the public through education realized that the scientist has discovered an increase of pollutant particles at the rate of 1,500 a year and that the level of 35,000 theoretically arrived at before 1990 will be deadly for humans.

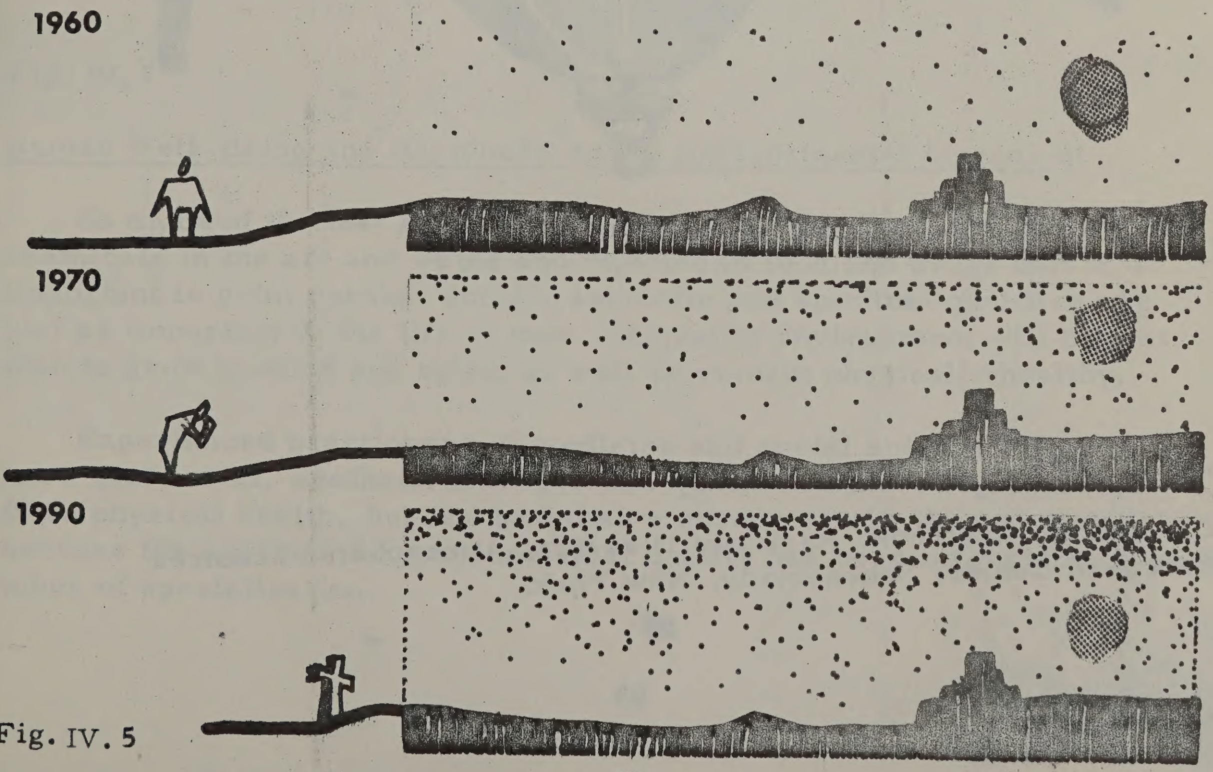


Fig. IV.5

An awareness of environmental quality might be sharpened even further if the public can be shown that a mask will be required of all people in the northern hemisphere by 1990 if the present pollution rate continues. (6)

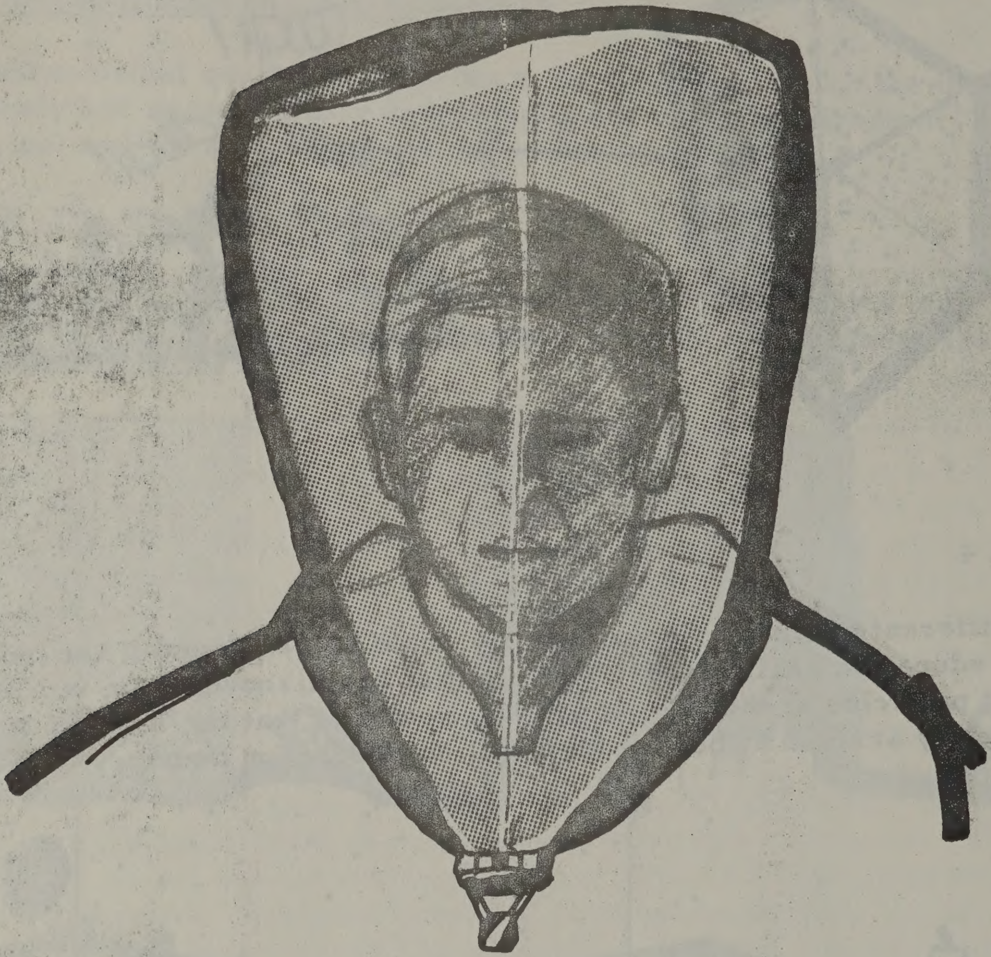


Fig. IV.6

---

(6) Dr. Alfred Hulstrunk, Assistant Director, Atmospheric Sciences Research Center, Schenectady, New York.

Survival: Food for Starving People

Building a new subdivision or highway across fertile Class A farmlands may not be considered environmental degradation by most in a nation burdened by temporary agricultural surpluses. But in nations where thousands die annually from starvation or in nations threatened by famine, the survival factor must consider such development as prime environmental degradation.

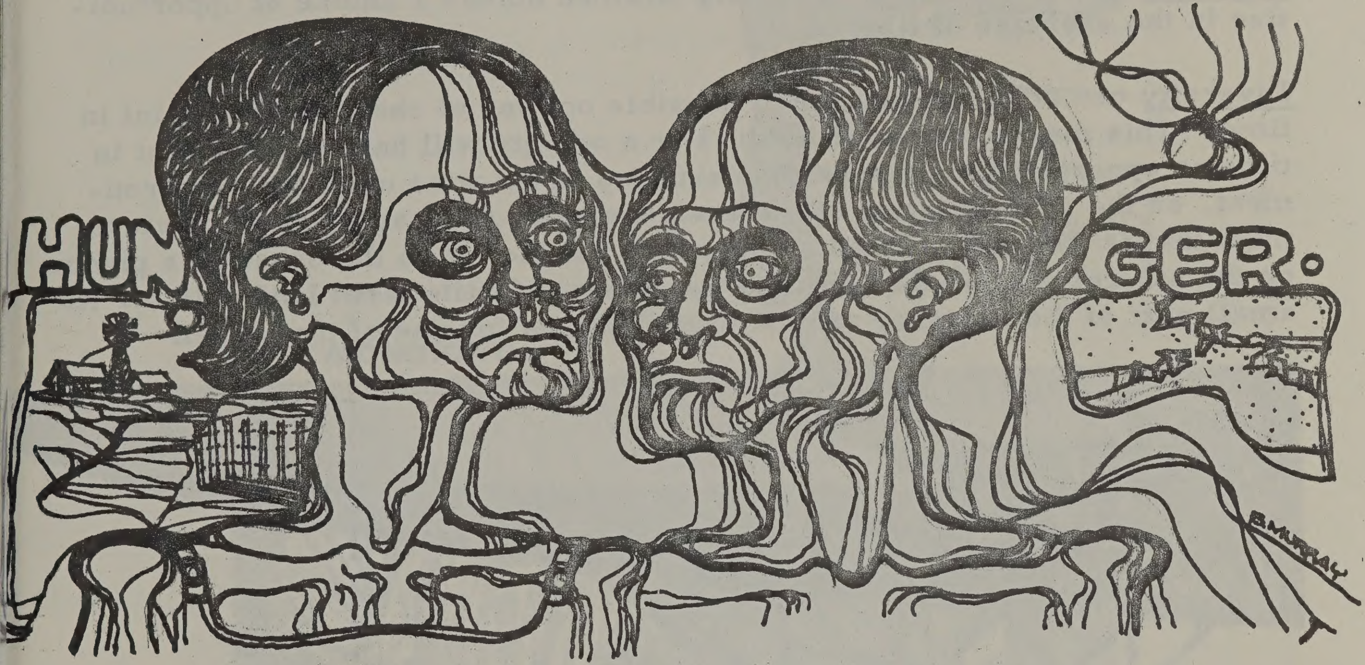


Fig. IV. 7

Human Well-Being and Happiness As An Environmental Ingredient

So much of the talk about environmental quality has been confined to chemicals in the air and water and injected in food and drugs that it is important to point out that social, aesthetic and spiritual qualities are just as important to the life of man. A quality environment will permit man to grow in mind and spirit as well as remain physically healthy.

Experienced practioners of medicine and social science already know that social, aesthetic and spiritual qualities cannot be separated from physical health, but few have had a chance to talk this way in public because the approach to environmental quality has been through the narrow tubes of specialization.

ENVIRONMENTAL DIVERSITY

There is enough evidence and philosophy in the history of man to conclude that diversity is one of the essentials of life, liberty and the pursuit of happiness.

Diversity is essential in the genetic pool to keep natural selection in the path of survival for the human specie.

Diversity is essential to provide the opposites in life. Without non-happiness or without unhappiness there could be no sensation of happiness.

Diversity is essential to give the big-brained human a choice of opportunities in the exercise of liberty.

Diversity can offer the maximum possible options of choice at any point in time. This means that an individual or a society will have at any point in time an opportunity to choose the next step in the wise use of his environment, or the rehabilitation of the environment. Any aspect of the environment that is finished, closed, discarded, whether it be the passenger pigeon or the natural prairie that created the nation's fertile farm lands, is for its small part of the universe an end to the options for use of that asset.

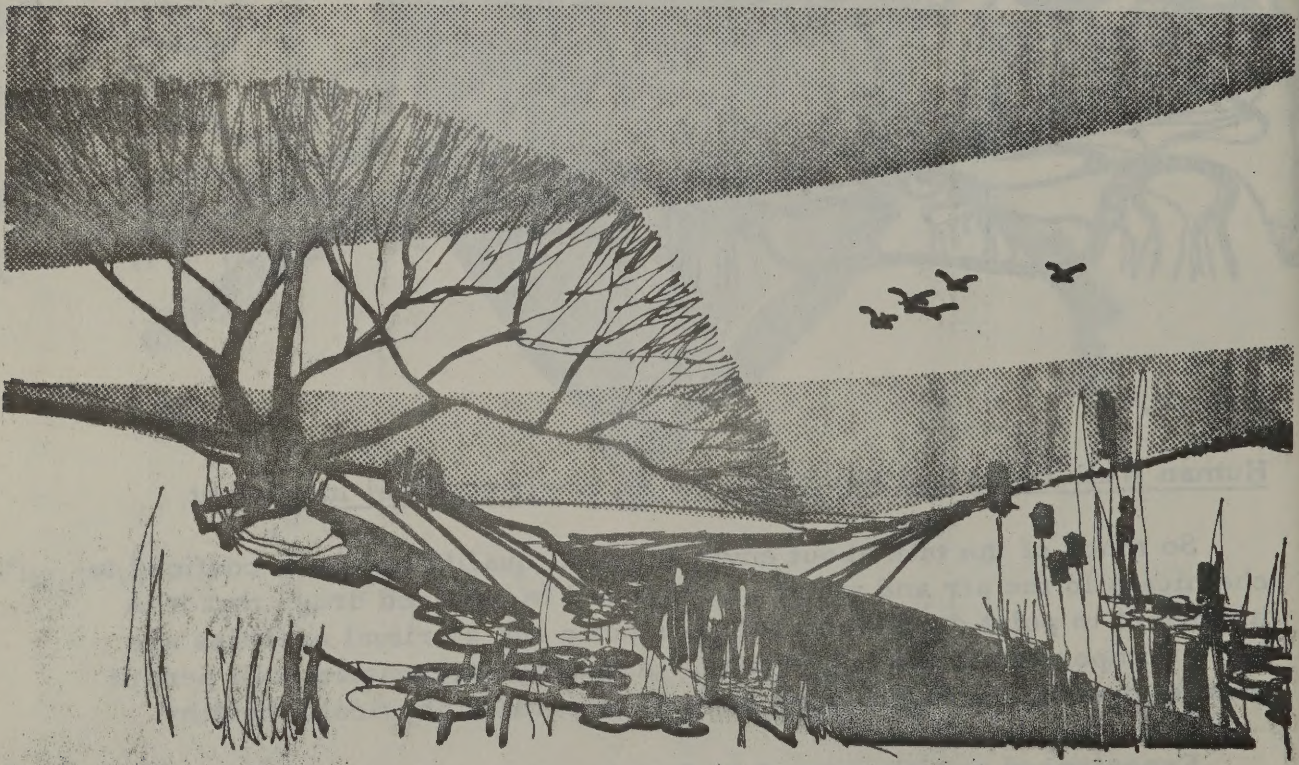
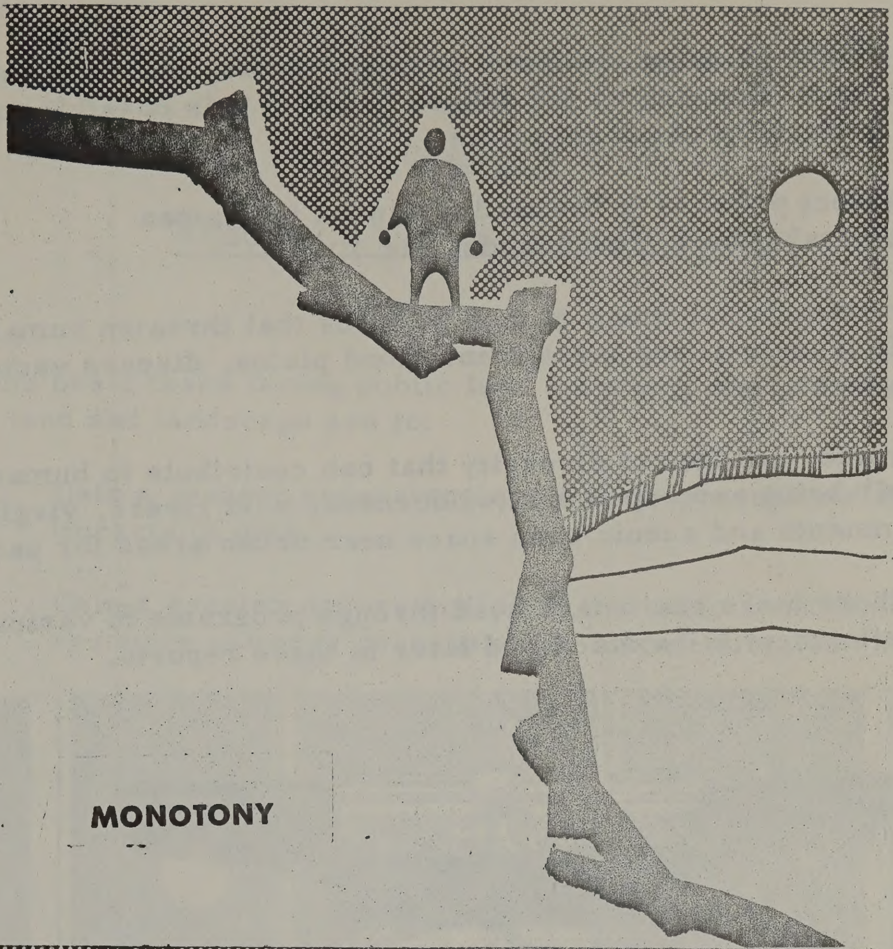
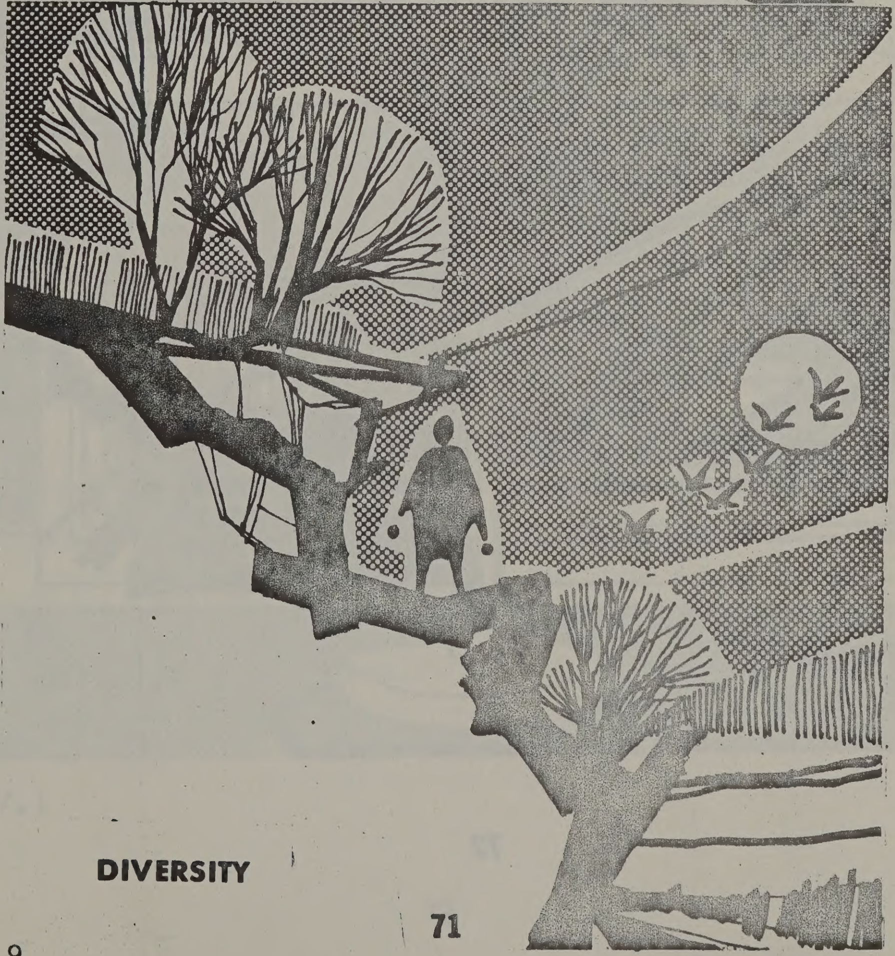


Fig. IV.8

Could we today recreate the prairies that provided our rich midwestern soils, which in turn provided us with vast agricultural wealth?



MONOTONY



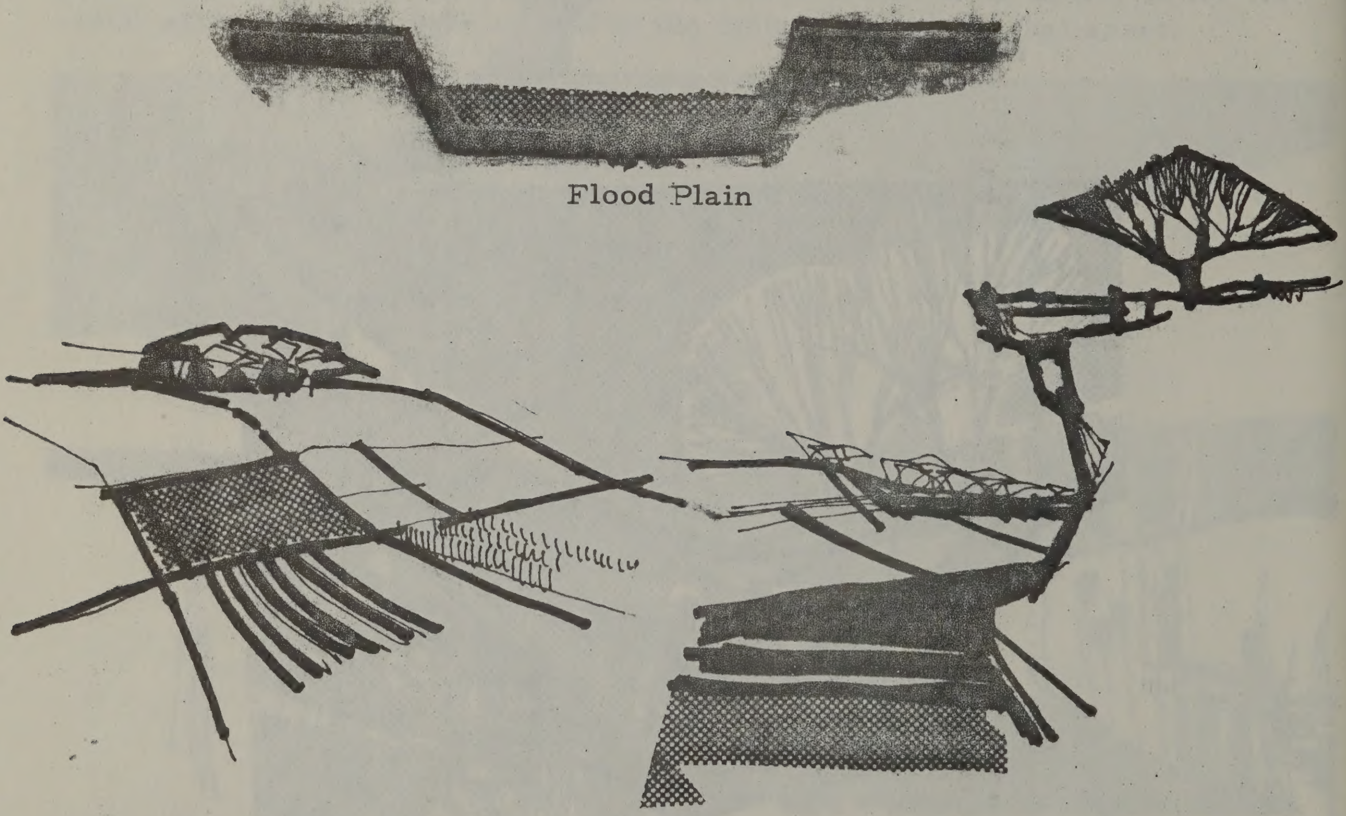
DIVERSITY

Fig. IV.9

From a land-planning viewpoint on public lands, environmental awareness, then, depends on the degree to which it is possible to develop an awareness of programs to:

1. Protect patterns in the land essential for human survival (Class A farmlands, etc.).
2. Prevent development of land patterns that threaten human life (survival) and investment (flood plains, disease vector patterns, etc.).
3. Protect patterns of diversity that can contribute to human well-being and happiness (wilderness, wild rivers, virgin timber remnants and scenic open space near urban areas for parks).

All of these tasks can be achieved through programs of various technical refinement to be discussed later in these reports.



Flood Plain

Crop Patterns

Diversity

Fig. IV.10

Chapter V

RESOURCE PATTERN RECOGNITION

The basic tasks facing public land managers and all other managers of the land and landscape are to:

1. Gain a greater understanding of past, present and future impacts of man.

2. Gain a greater understanding of the basic environmental resource patterns necessary for human survival, well-being

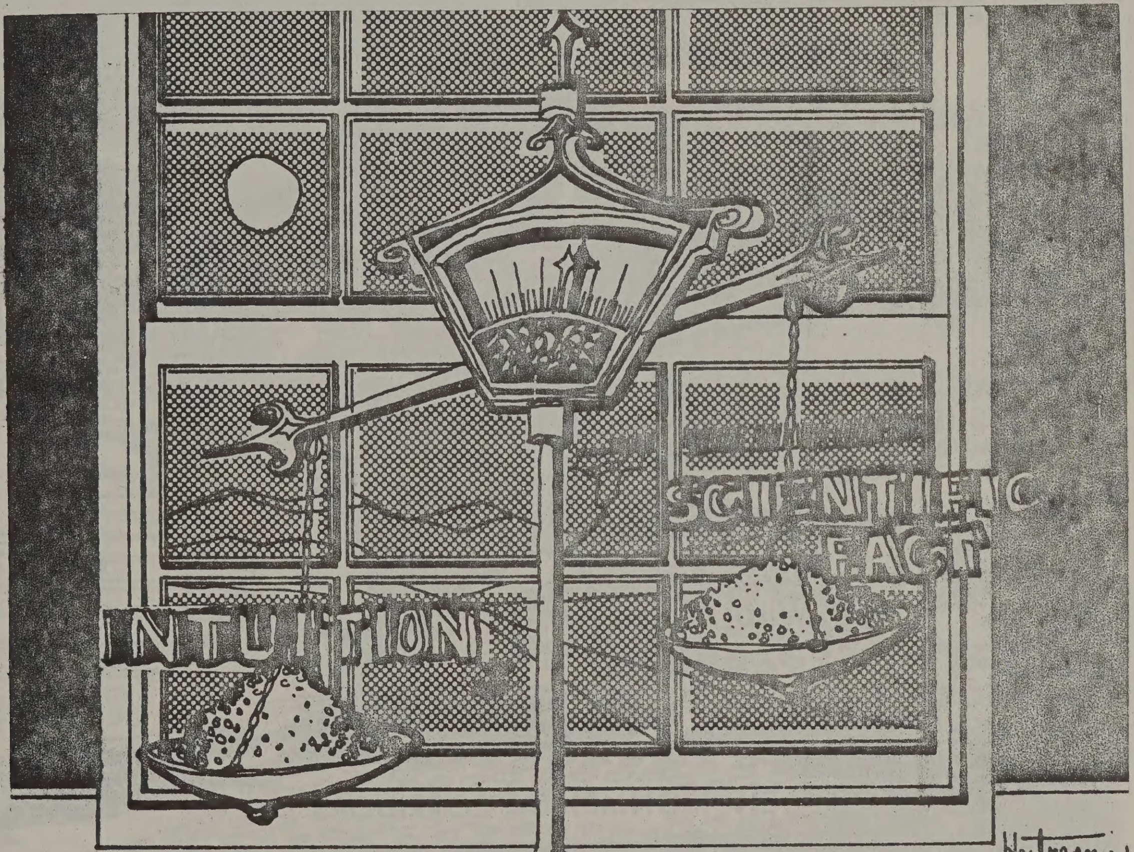


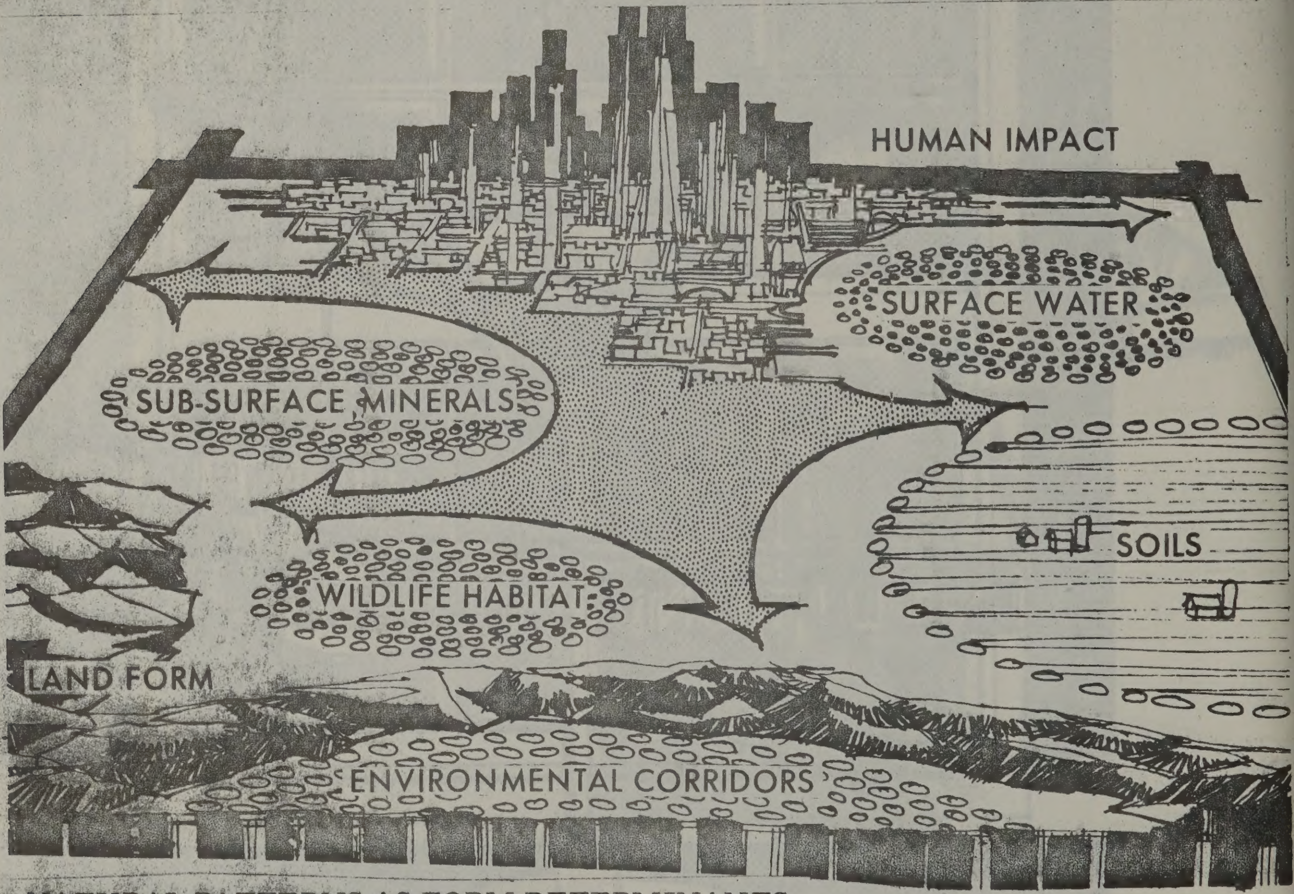
Fig. V.1

and happiness. (As has been pointed out, this understanding may well have to be subjective for the immediate future.)

A third task might be to recognize that these resource patterns can be considered to be "Where Not to Build Patterns" until it can be demonstrated through future environmental research that they are not needed for human survival, well-being and happiness.

FORM DETERMINANTS

In most developing regional planning programs, these resource patterns are called form determinants for they can be used to guide the structure and form of various human impacts whether they be highway ribbons or fields of tract houses. First, of course, they must be recognized and plotted.



NATURAL PATTERNS AS FORM DETERMINANTS

Fig. V.2

PATTERNS THAT CAN DIRECTLY THREATEN HUMAN LIFE AND INVESTMENT

Some form determinant factors are of a nature that can directly threaten human life and investment. These are:

1. Weather patterns

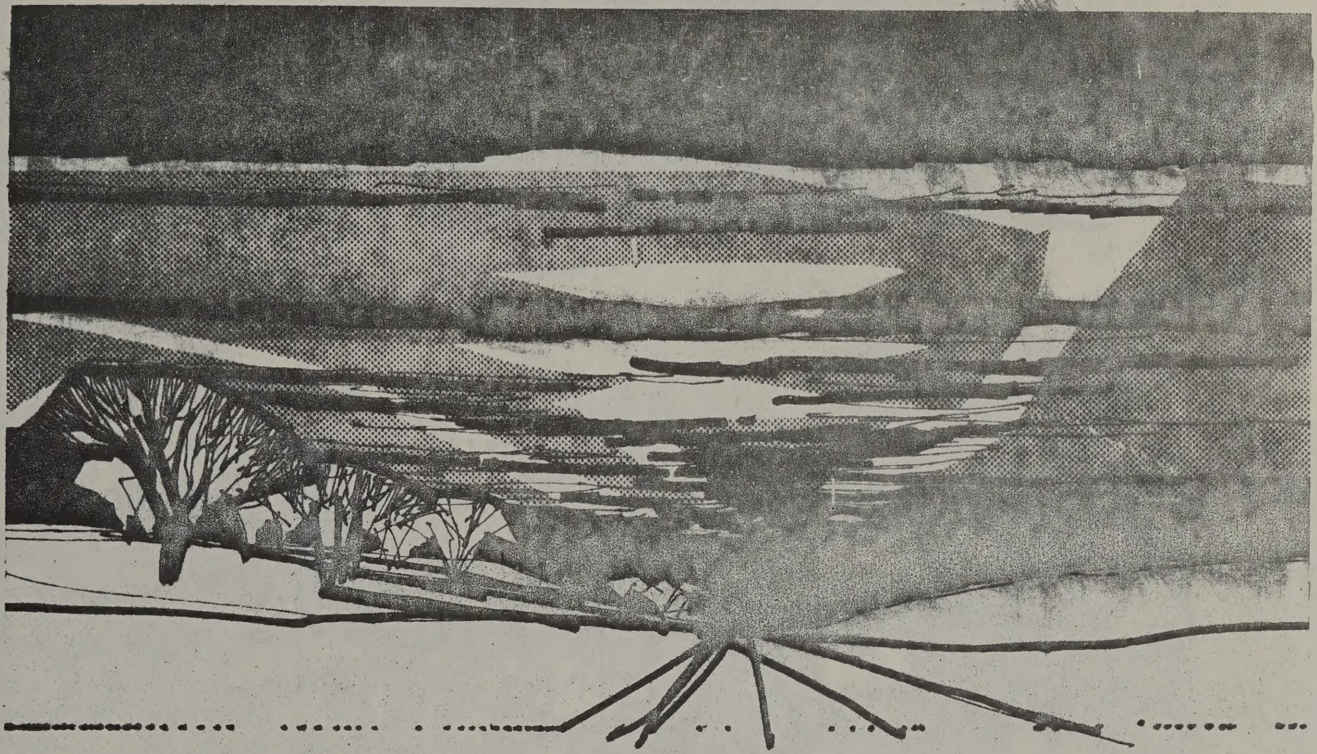


Fig. V.3

Weather Patterns

By understanding the various patterns of weather it may soon be possible to predict with extreme accuracy future paths of storms, forewarning farmers and urbanites of potential crop and property losses. Today some highways are still built within snow belts when a new alignment but a few miles further south would save them from the hazards of slippery driving, loss of life and limb, and the cost of extensive snow removal.

2. Toxic patterns
3. Fire hazard patterns

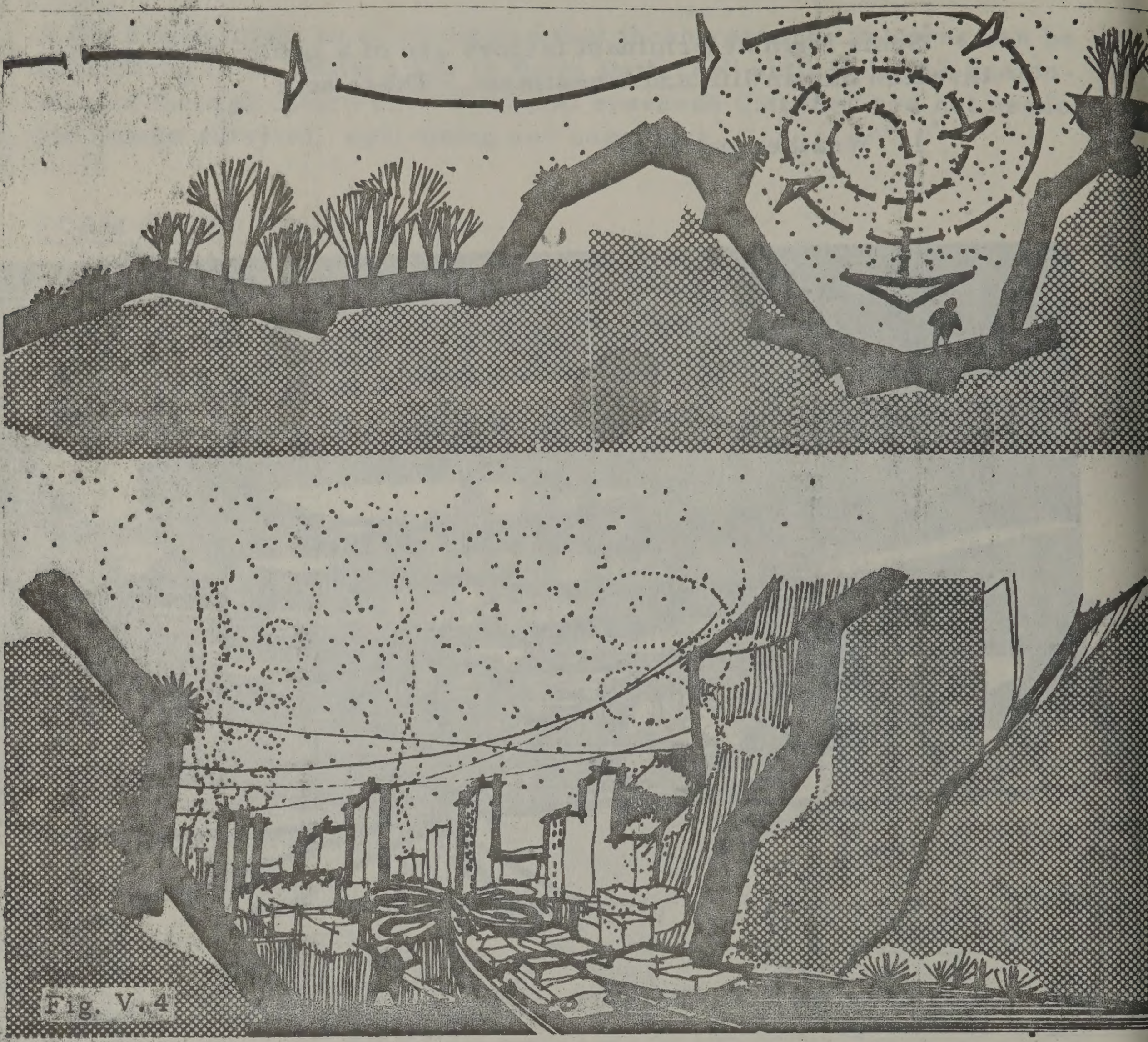


Fig. V.4

Toxic Patterns

By observing combinations of predictable wind patterns and land form patterns experts can suggest where temperature inversion layers are most likely to exist. When concentration of internal combustion machines pour carbon monoxide, carbon dioxide and other poisonous gases into inversion layers, they can become a most serious problem to human habitation within.

4. Flood patterns

5. Disease vector patterns

6. Human waste and disposal patterns

7. Volcanic-earthquake patterns

Identification of these form determinant patterns on all public lands, especially in areas subject to present and projected impact is essential if we are to guide impact wisely.

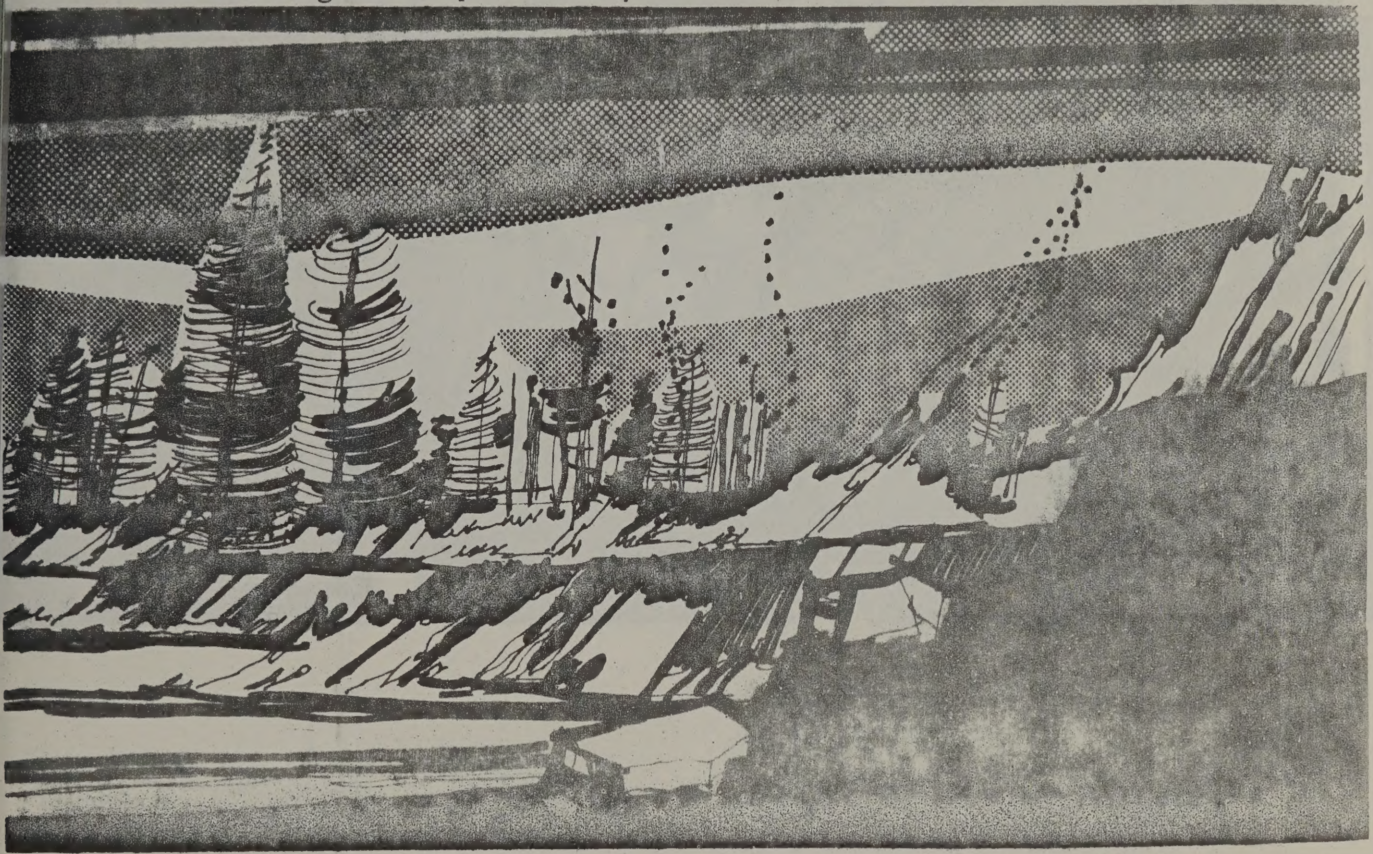


Fig. V.5

Fire Hazards Patterns

It is relatively simple to identify textural landscape patterns that in a dry season become highly inflammable and threaten all forms of life within their boundaries. Forest fires and grass fires destroy hundreds of homes each year because man through ignorance or gamble still chooses to build within these scenic but dangerous patterns.

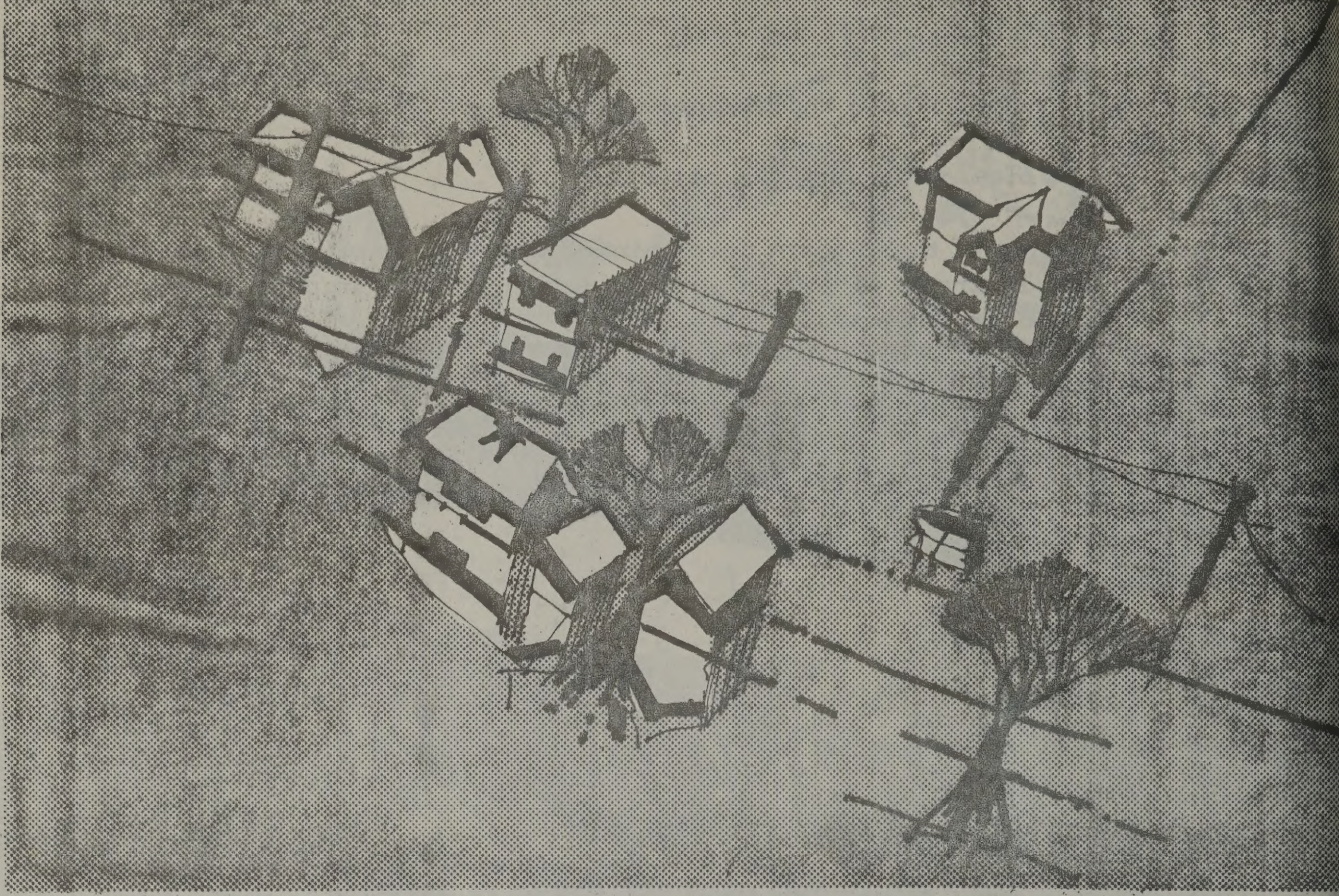


Fig. V.6

Flood Patterns

High water marks graphically portray the fringe areas of past water patterns created by early thaws and spring rains or the ravaging waters of hurricanes and tidal waves. To build within such patterns invites certain loss of property and possible loss of life.

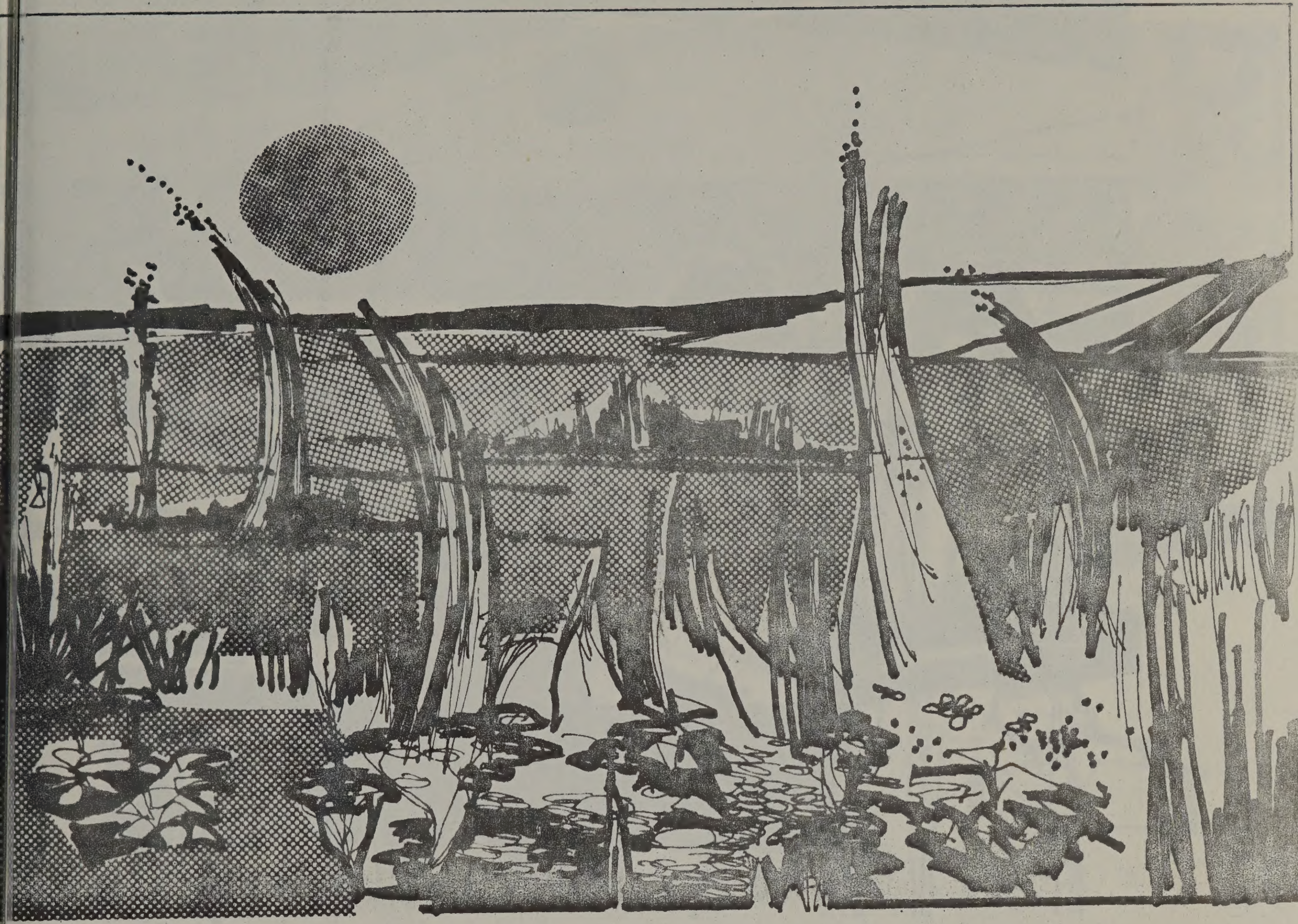


Fig. V.7

Disease Vector Patterns

Certain landscape patterns serve as habitat for disease carrying insects that transmit sickness to man. An increasing effort to study and understand these habitats will furnish additional guidelines for human habitation patterns.

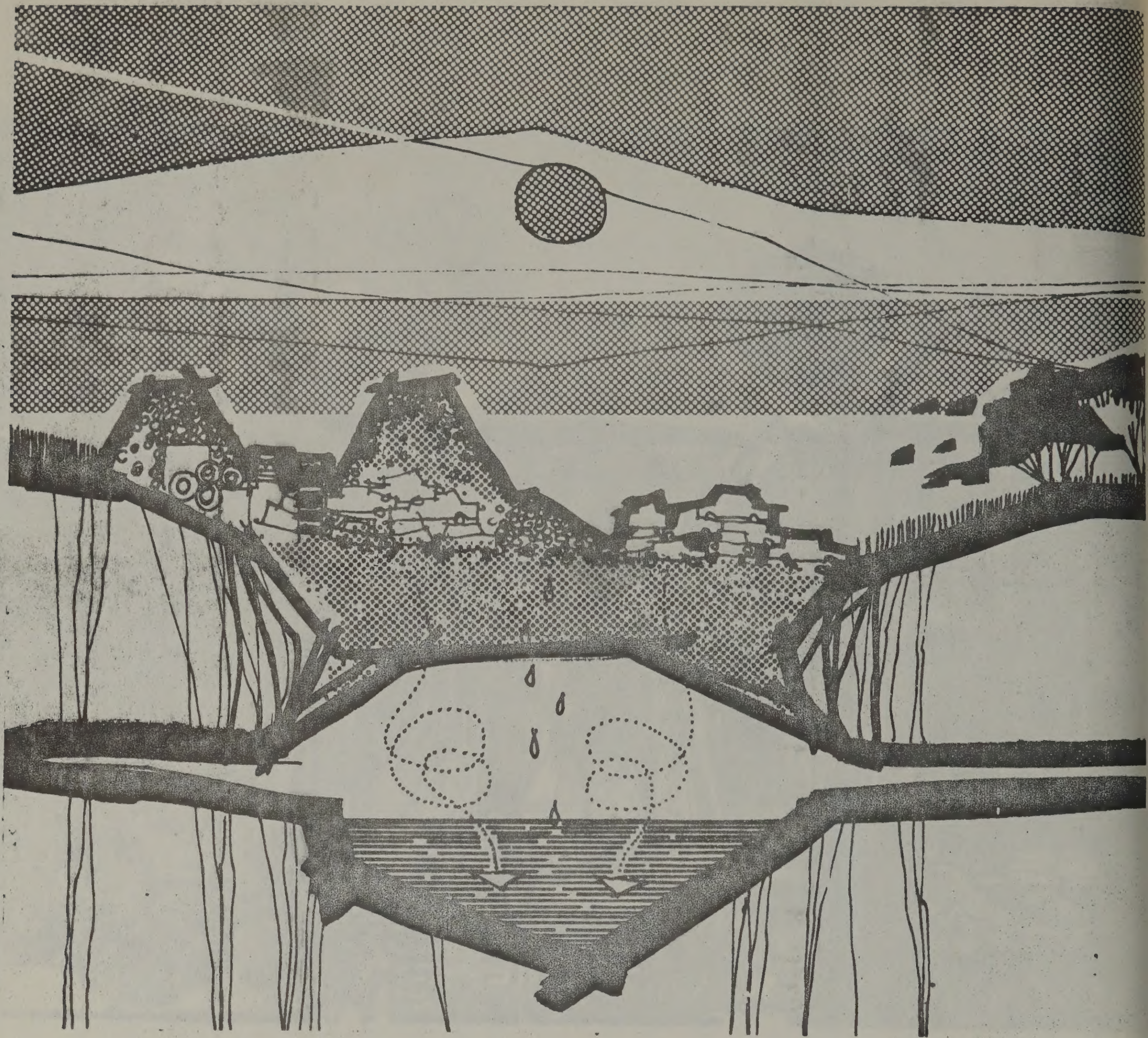


Fig. V.8

Human Waste and Disposal Patterns

Few people today, if asked, could identify where in a university or industrial community all past wastes from chemistry and research labs have been disposed. Some, no doubt, have been unwisely located above geological formations, making it possible for seepage to pollute underground water supplies. Offensive odors from such areas can also make human occupation impossible.

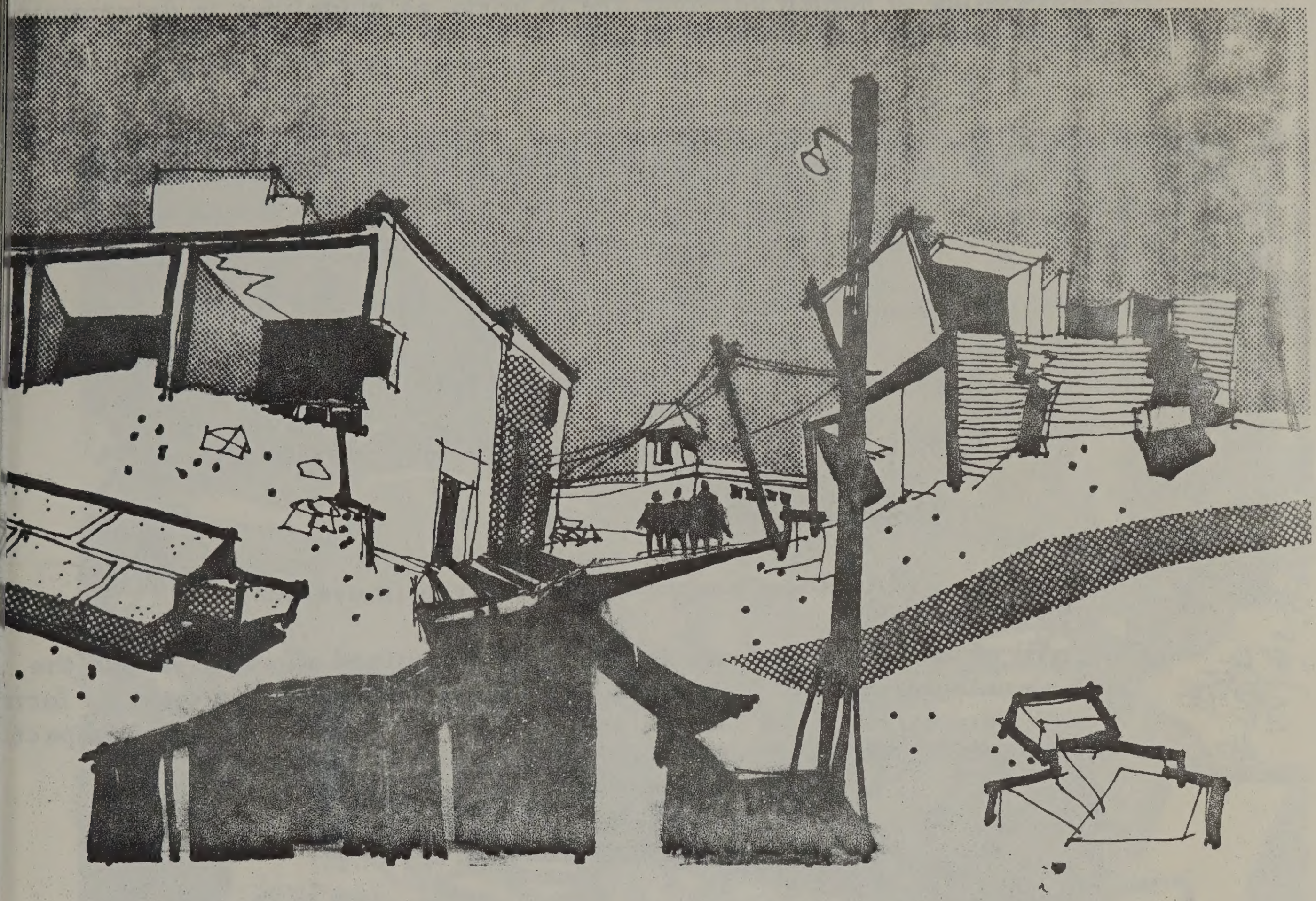


Fig. V.9

Volcanic-Earthquake Patterns

Each year there is loss of life and property because man locates his human use patterns in the paths of potential lava flows or straddles unstable vault lines. Homes, highways, campgrounds, and whole cities have been known to suffer severely because of such improper location.

PATTERNS THAT OFFER HOPE FOR SURVIVAL

The following patterns that directly and indirectly offer hope of survival must be understood by land managers if considerations relating to human survival are to serve as guidelines in determining long-range use of public lands.

1. Cropland patterns (food)

2. Scientific patterns (food-drugs)

3. Potential reservior patterns (water)

4. Ground water patterns (water)

5. Aquifer recharge patterns (water)

6. Building material patterns (shelter, industrial use)

7. Mineral resources (industry)

8. Utility and transportation patterns (movement)

All of these patterns are fairly well recognized as important in the planning process. Yet few have been inventories and plotted as form determinants in the paths of expected urban and recreational impact.

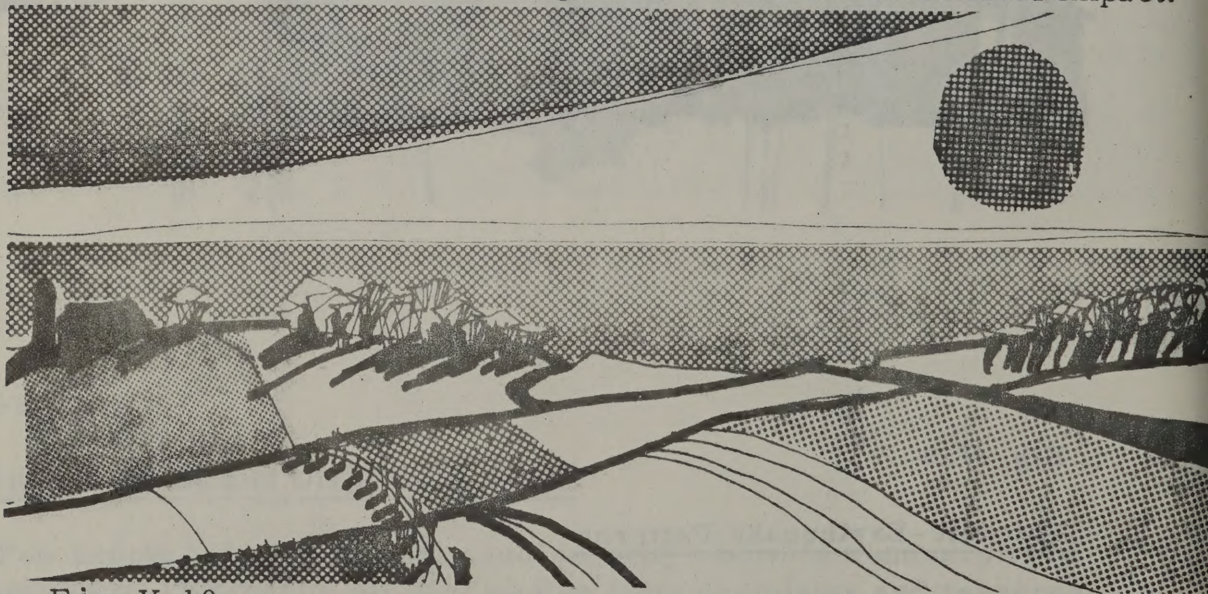


Fig. V.10

Cropland Patterns

The soil scientist has identified patterns of soils that, in their present state or with the addition of fertilizers, offer the best opportunity for food and fiber production. As populations explode around the world, many areas may well face famine and starvation within the next five to ten years. These most productive soils must be protected from human encroachment and maintained for even higher production through new agricultural technology.

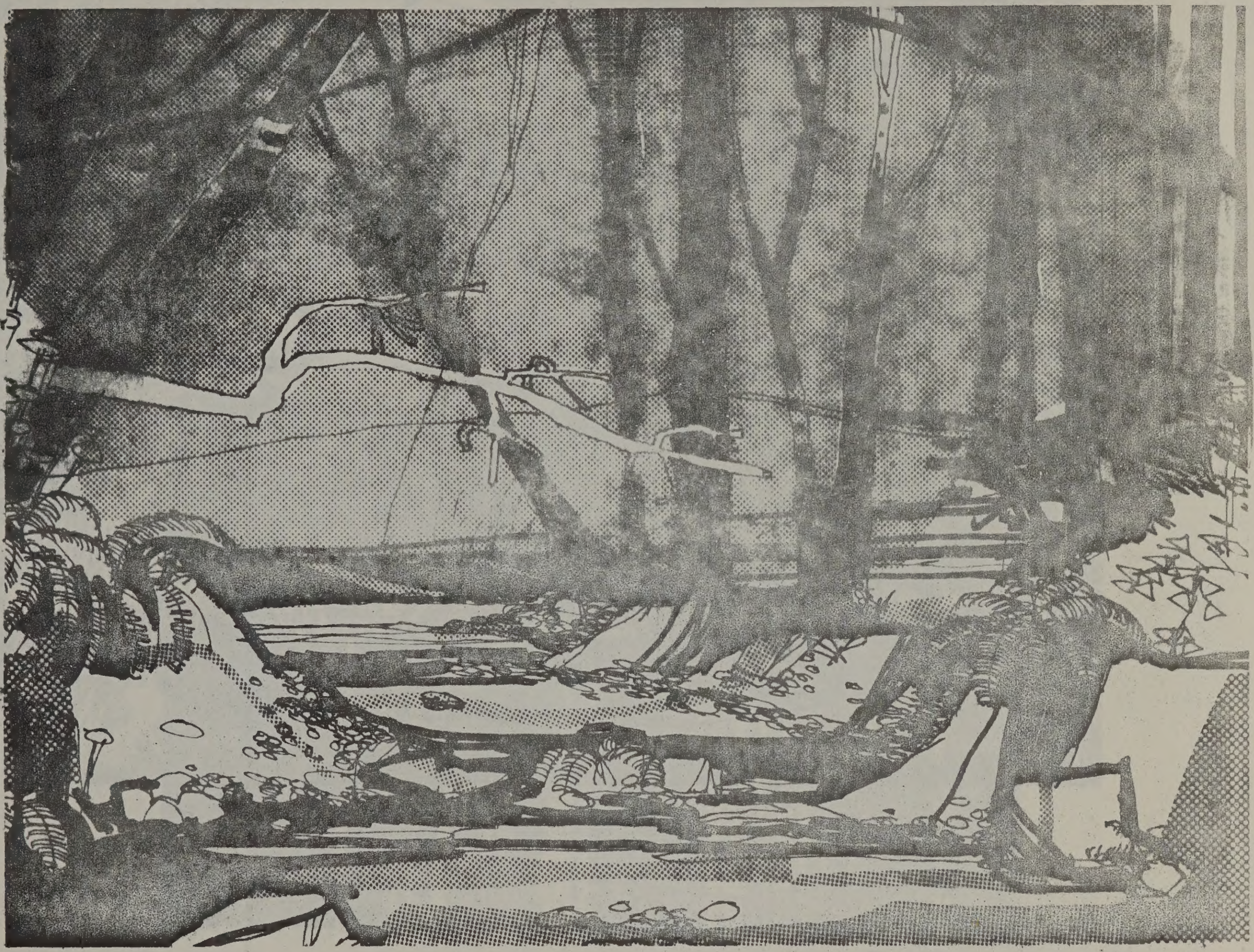


Fig. V.11

Scientific Patterns

In the analysis of various landscapes it is apparent that only small remaining areas of landscape are as yet relatively untouched by the axe and plow. Science needs these natural areas as check points; medicine and agriculture may still find in these natural patterns new drugs and new crops; and mankind can always profit in the relief these many natural textures afford from the brick, steel, glass, and asphalt of our cities. These area-wide patterns might vary from one tenth of an acre to many thousands in various parts of the country.

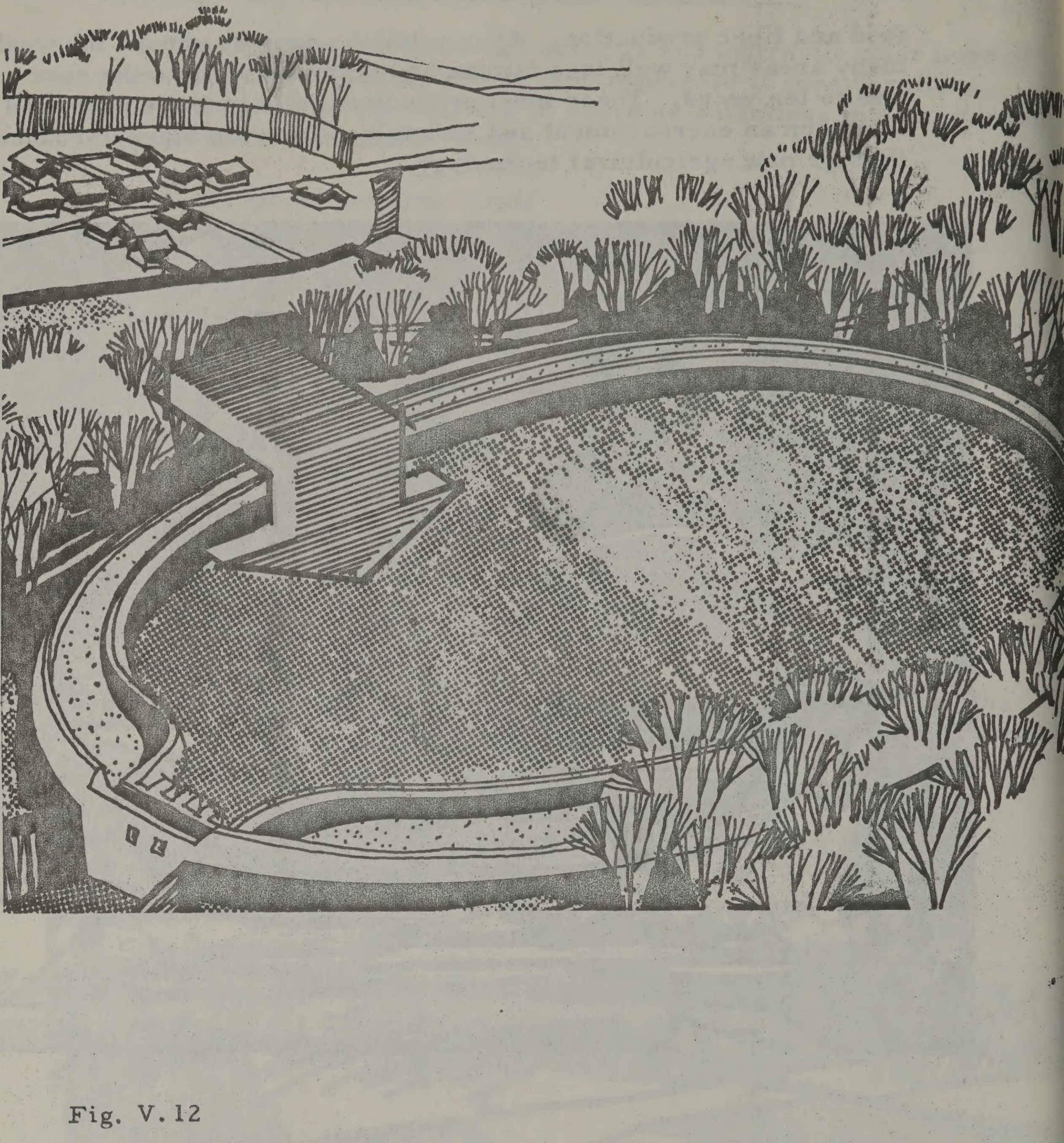


Fig. V.12

Potential Reservoir Patterns

Water supplies have become extremely limited in many parts of the world and will depend on new reservoir systems. In considering new reservoirs, land forms that create natural bowls and can easily be developed must be reserved. These patterns must be identified and protected from urban encroachment if they are to serve as new sources of water.

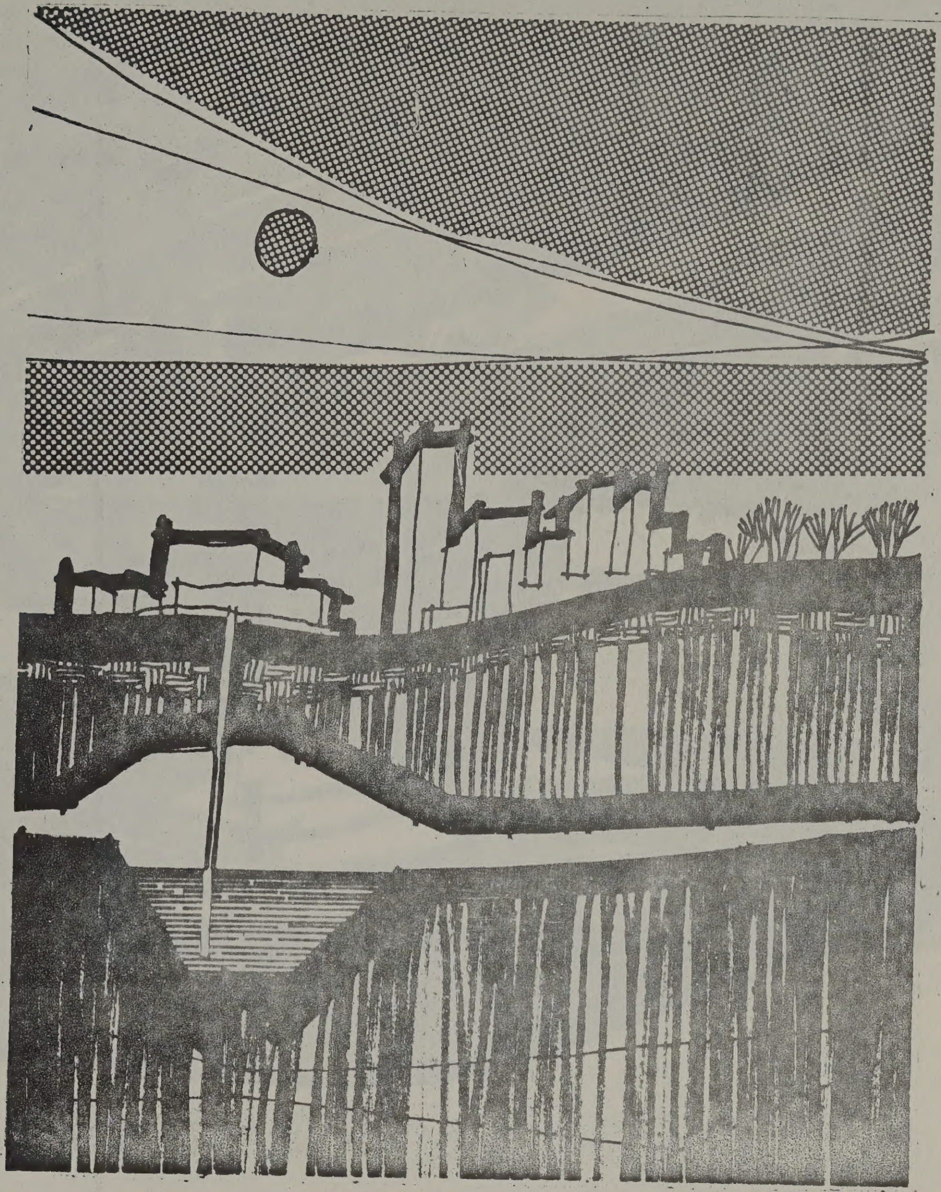


Fig. V.13

Ground Water Patterns

Geologic processes have created beneath the land's surface underground water storage systems. Since they contain much of man's future water supply, it is vitally important to know where these patterns are.

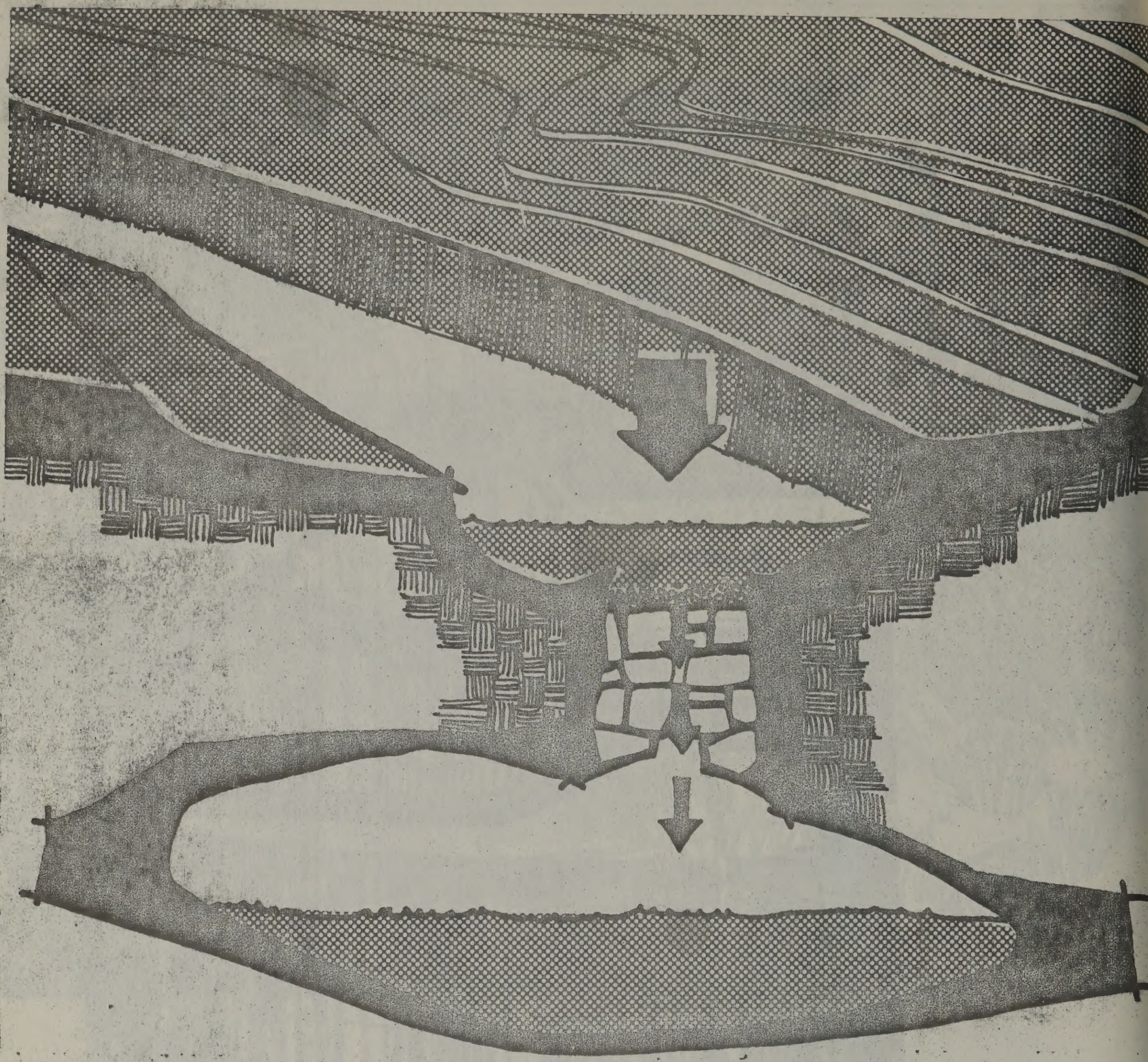


Fig. V. 14

Aquifer Recharge Patterns

Within many of the landscapes are aquifer recharge patterns. These are basically porous patterns that permit surface waters to penetrate the surface of the landscape and refill the natural underground storage systems. Protected from high density development, and assuming a normal rainfall, underground storage systems will continue to provide drinking water for present and future generations.

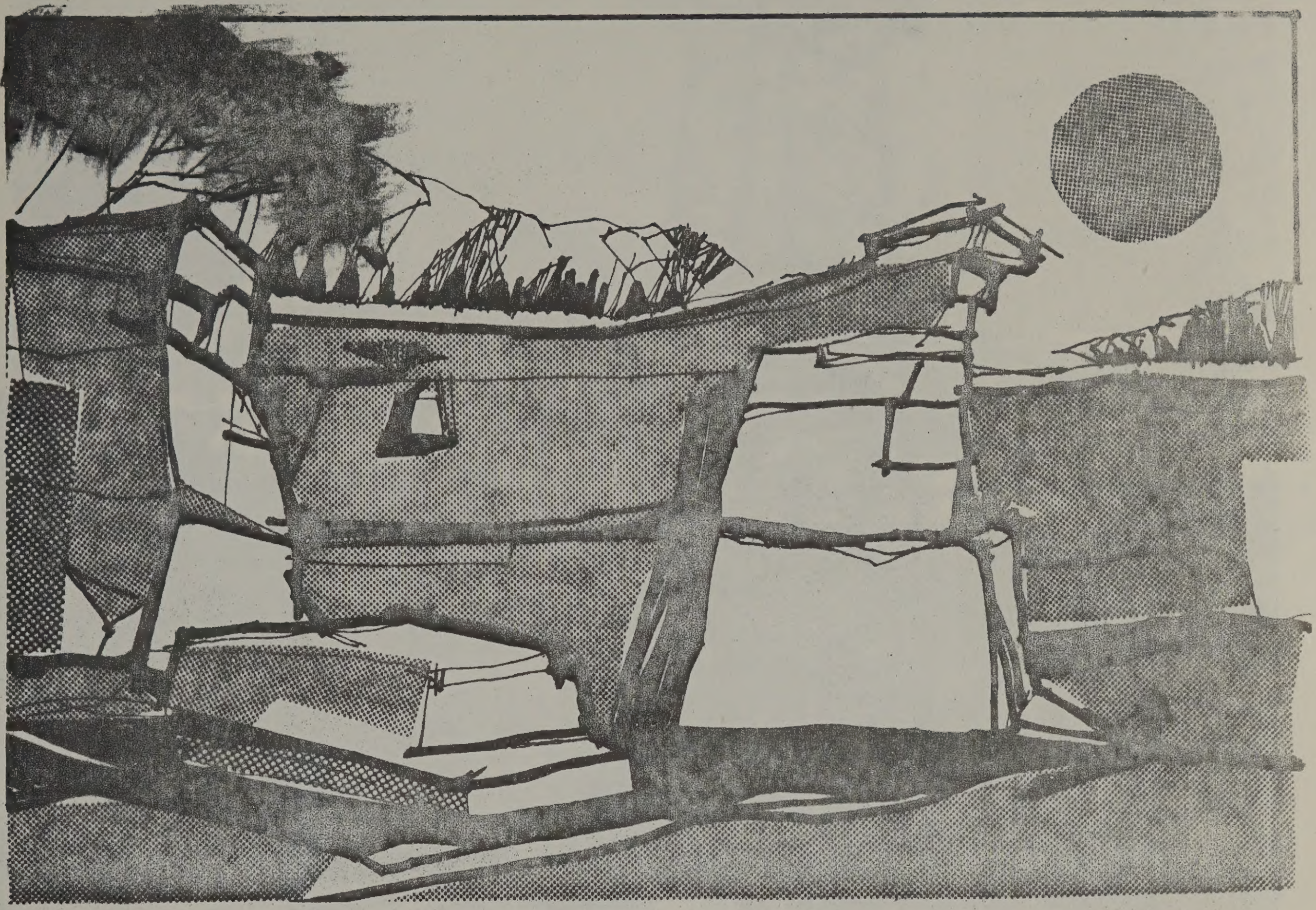


Fig. V.15

Building Material Patterns

In many landscapes the geologist has identified patterns of sand, gravel, limestone, and other minerals necessary for the construction and reconstruction of expanding cities and transportation networks. Human encroachment should be prevented above these valuable deposits if an economic supply is to be near expected development.

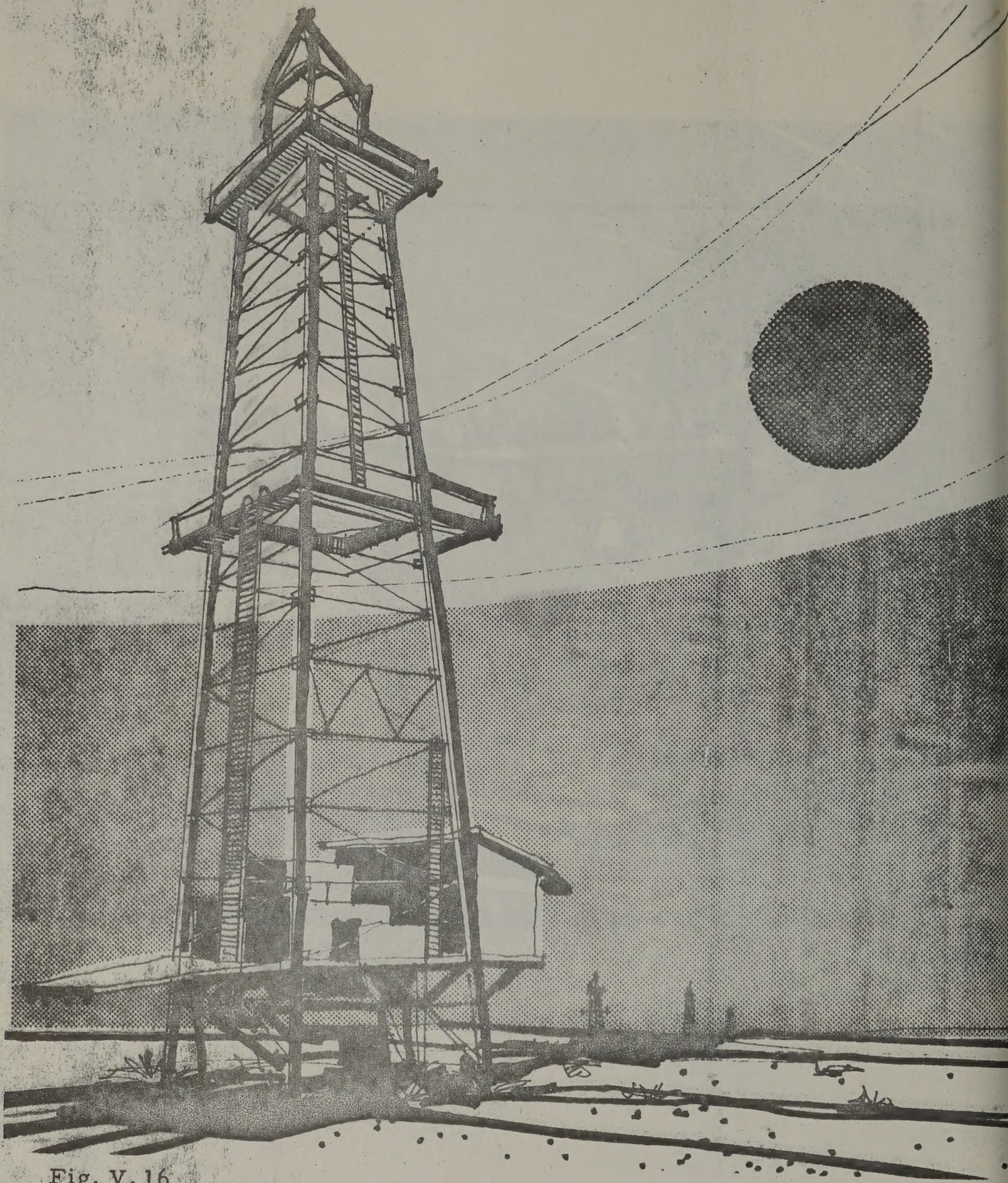


Fig. V.16

Mineral Resources

Oil, natural gas, coal and other subsurface resources are needed to meet the expanding requirements of industry and home comfort. Much more carefully planned development of these resources on public lands is a necessary conservation measure.

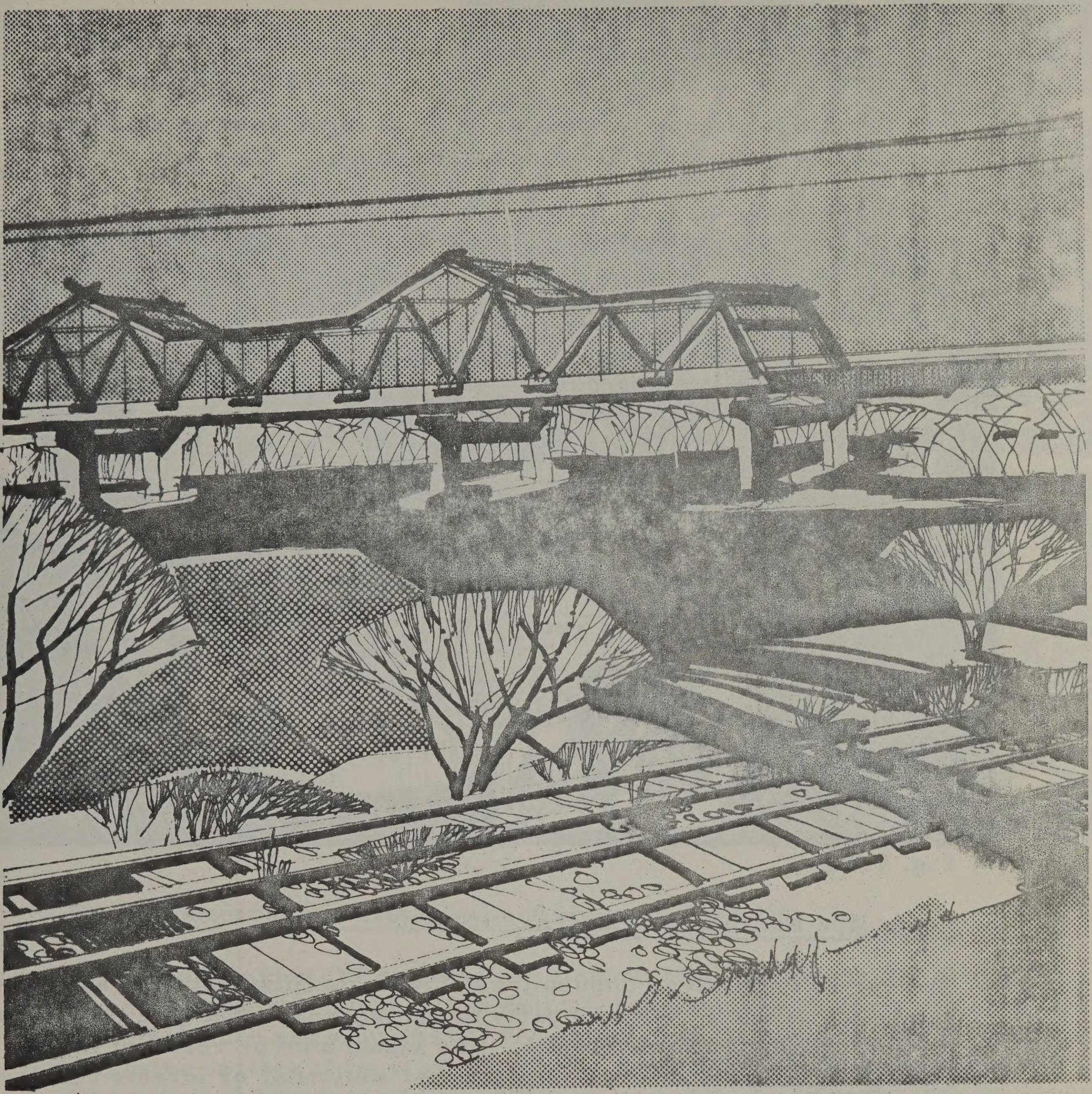


Fig. V.17

Utility and Transportation Corridor Patterns

Environmental and functional factors can suggest the most logical patterns for future utility lines, street extensions, and highway alignment. These corridors must be identified and protected from other urban uses if these systems are to be developed in a comprehensive way for the future.

PATTERNS THAT OFFER HOPE FOR HUMAN WELL-BEING AND HAPPINESS

Certain landscape patterns have great capacity or potential for contributing to human well-being and happiness. They are:

1. Landscape personalities

Fig. V.18

Landscape Personality Patterns

The varied forms and combinations of man-modified natural resources can be identified in different parts of the landscape that give each area its distinguishing characteristic. The visual sum or result of these combined patterns of water, topography, wetlands, or forests results in a unique series of regional personalities. The various three dimensional-visual patterns of agricultural production, urbanization (townscape), and transportation, also have their own unique personality patterns and add to the perceptual patchwork that is our environment.

Contemporary construction reflecting local qualities of texture, color, and pattern and not a uniform, so-called modern style should be encouraged. The landscape heritage is worthy of expression through varied architecture in harmony with this heritage.

2. Ethnic patterns

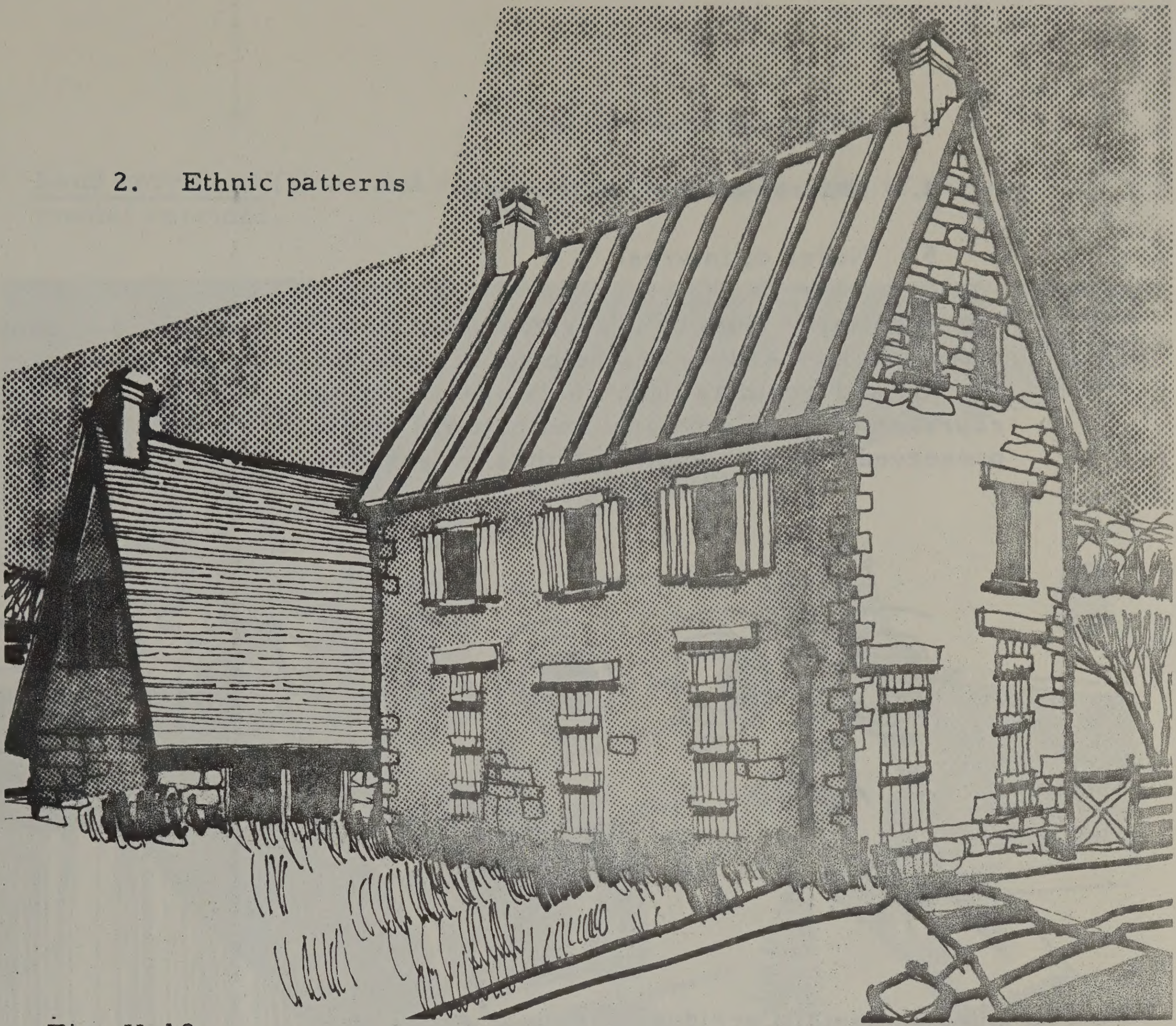


Fig. V.19

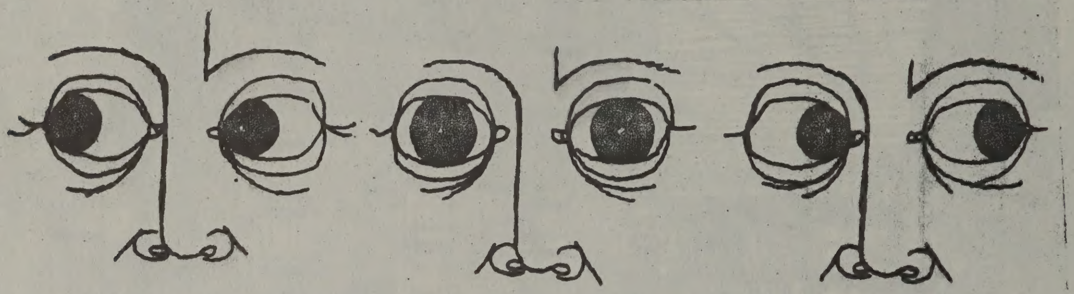
Ethnic Patterns, Archeological and Historic Features

Several other kinds of patterns are important to environmental planning and development. Studies have indicated the variety of ethnic patterns and other such activities which are a part of our national heritage; an extensive variety of local architecture, cooking, handicrafts, customs, museums, and holidays exists within these cultural patterns. This variety is important to environmental quality and needs continued recognition if it is not to be submerged in the current tendency toward conformity.

The historic identity serves not only as a valuable environmental quality and as a tie with the past, but serves also as an important recreational and tourist attraction. It is a heritage not to be exploited, but to be protected and valued. It can continue to help make life interesting and pleasant to both residents and visitors.

3. Environmental corridors
4. Natural and cultural values
5. Nodes of interest

These patterns must be understood, protected and enhanced by land managers so that they can help Americans nourish their sense of identity and worth as individuals and as a nation. The many options represented by this natural and cultural diversity should also be preserved for the benefit of future generations.



Environmental Corridors

Environmental corridors are simply a pattern of "remaining nature" as yet relatively untouched by the plow, saw and blade. Protected and developed wisely, these corridors offer future generations the same natural and cultural amenities that present generations enjoy today.

Within these patterns are found the unifying elements of nature (e. g., color, texture, pattern and scale), a living organic and changing pattern that offers variety and serves as an all-prevading environmental network that makes the often haphazard mis-designs of man tolerable.

The natural elements within the corridors are the same as those brought back only a great cost in major redevelopment and renewal programs. On the pages that follow the major environmental corridor patterns are illustrated and briefly described.

Land corridors (slope and rims) constitute a basic form of environmental corridor.

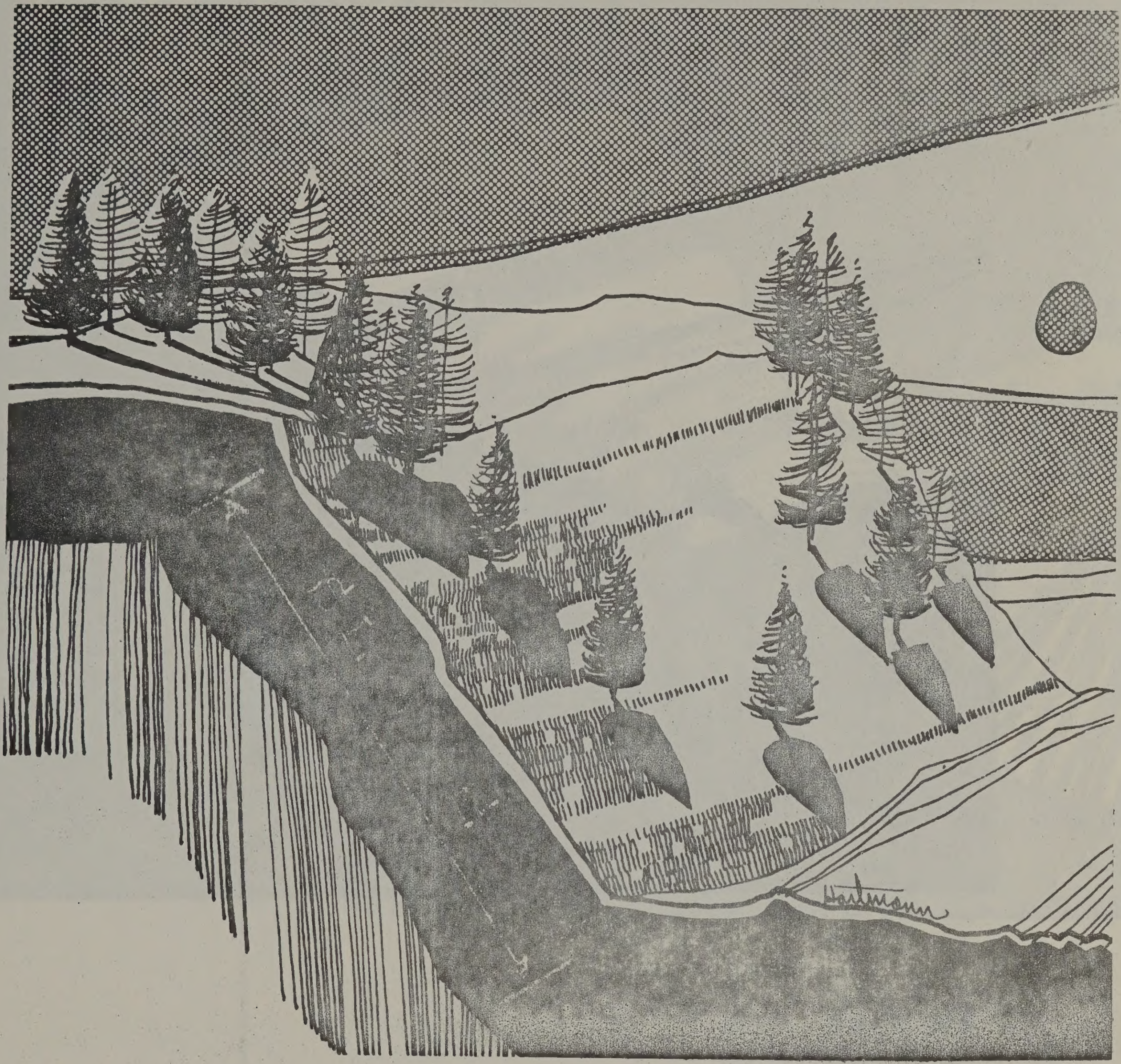


Fig. V.20

The basic landscape features that separate ridge-tops from their valley floor are known as slope. There has been scientific support that the farming of slopes of over 12 1/2 per cent often creates serious soil erosion problems.

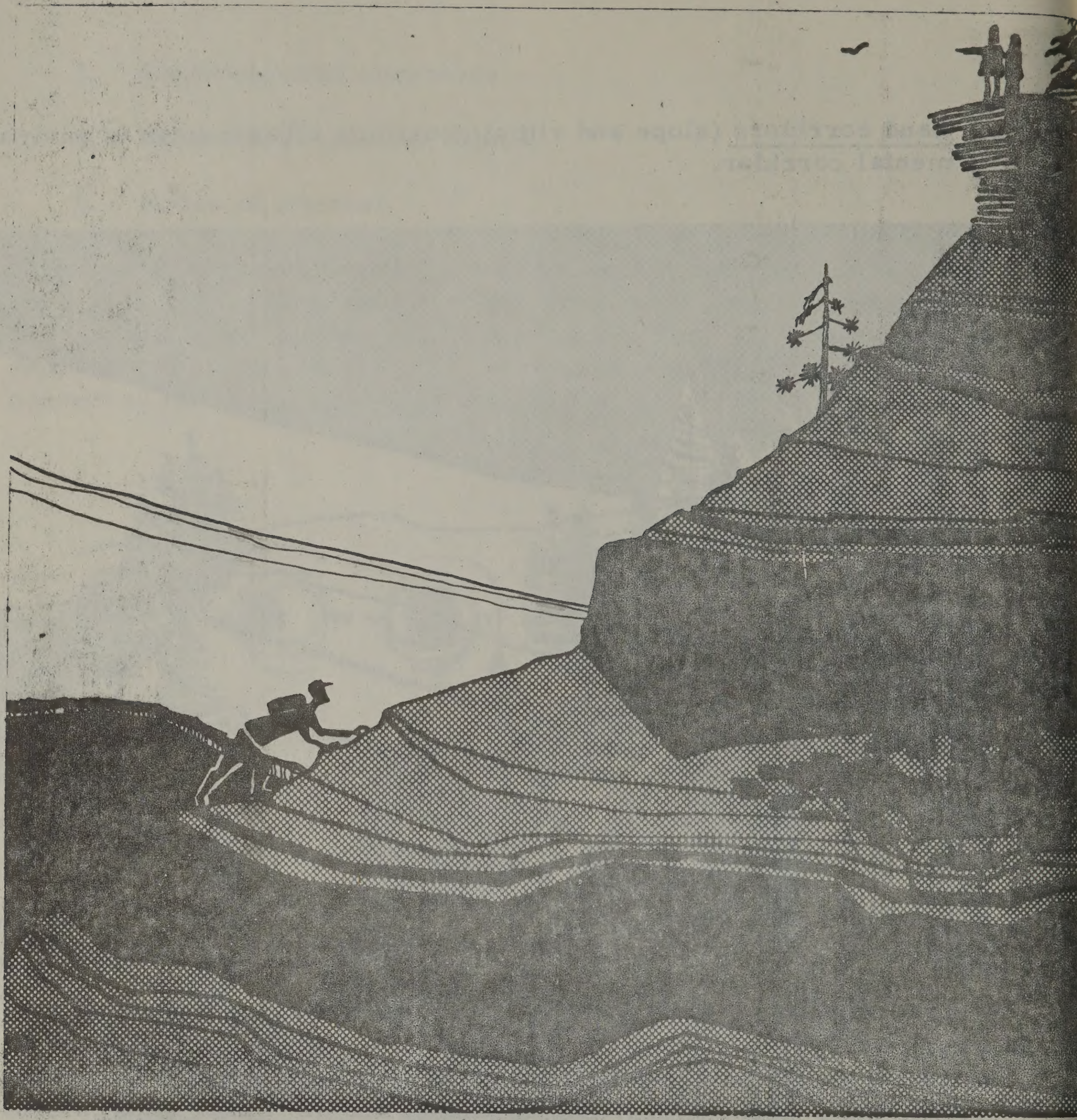


Fig. V.21

The land may be too steep to plow, but for a man it is a place to scale either in body or in mind. The fact that slope patterns have been difficult to scale has protected them from heavy human impact. On many public lands, they remain, offering natural patterns of resource diversity for human enjoyment.

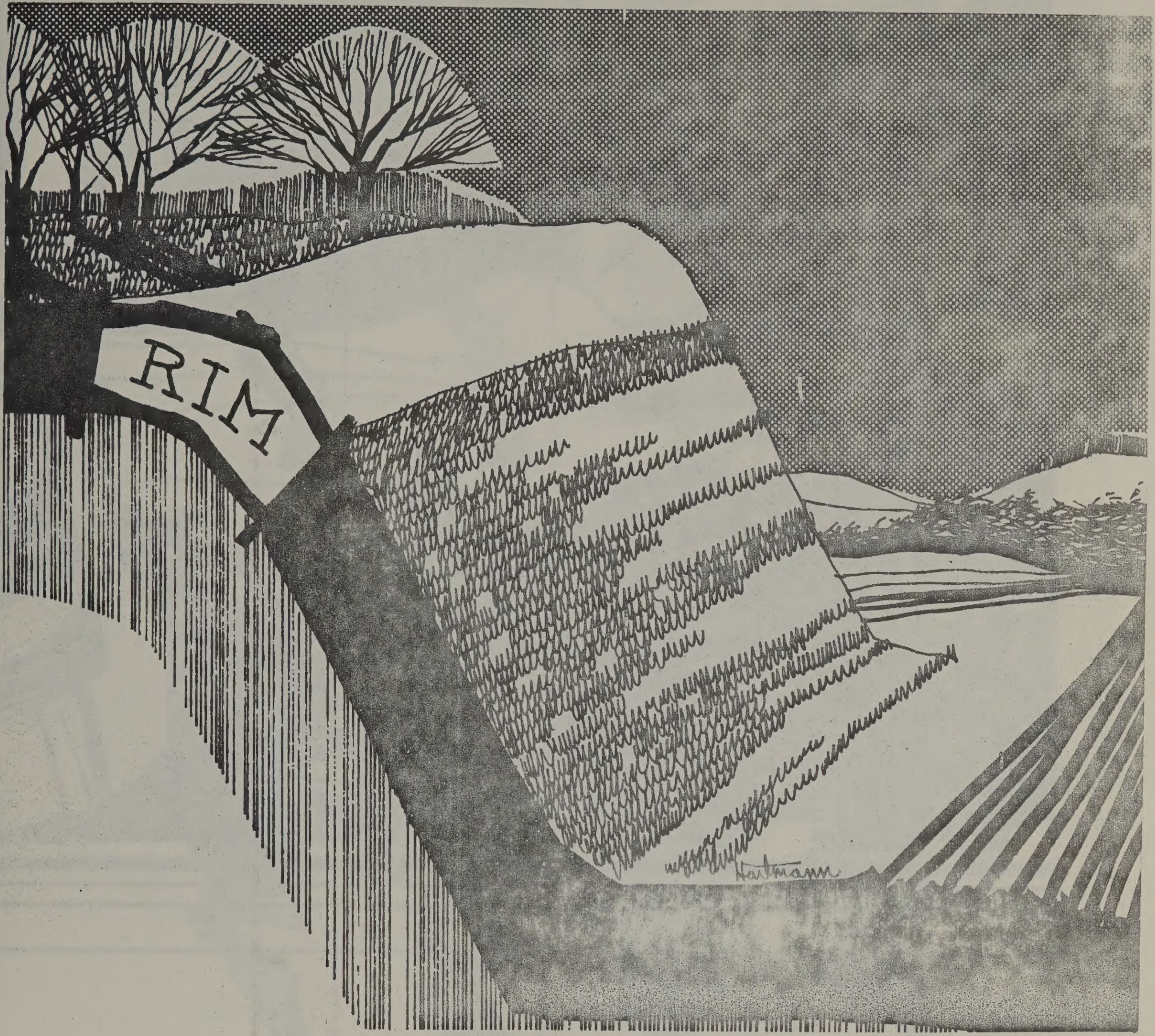


Fig. V.22

At the upper most edge of a slope can be seen what might be called a rim.

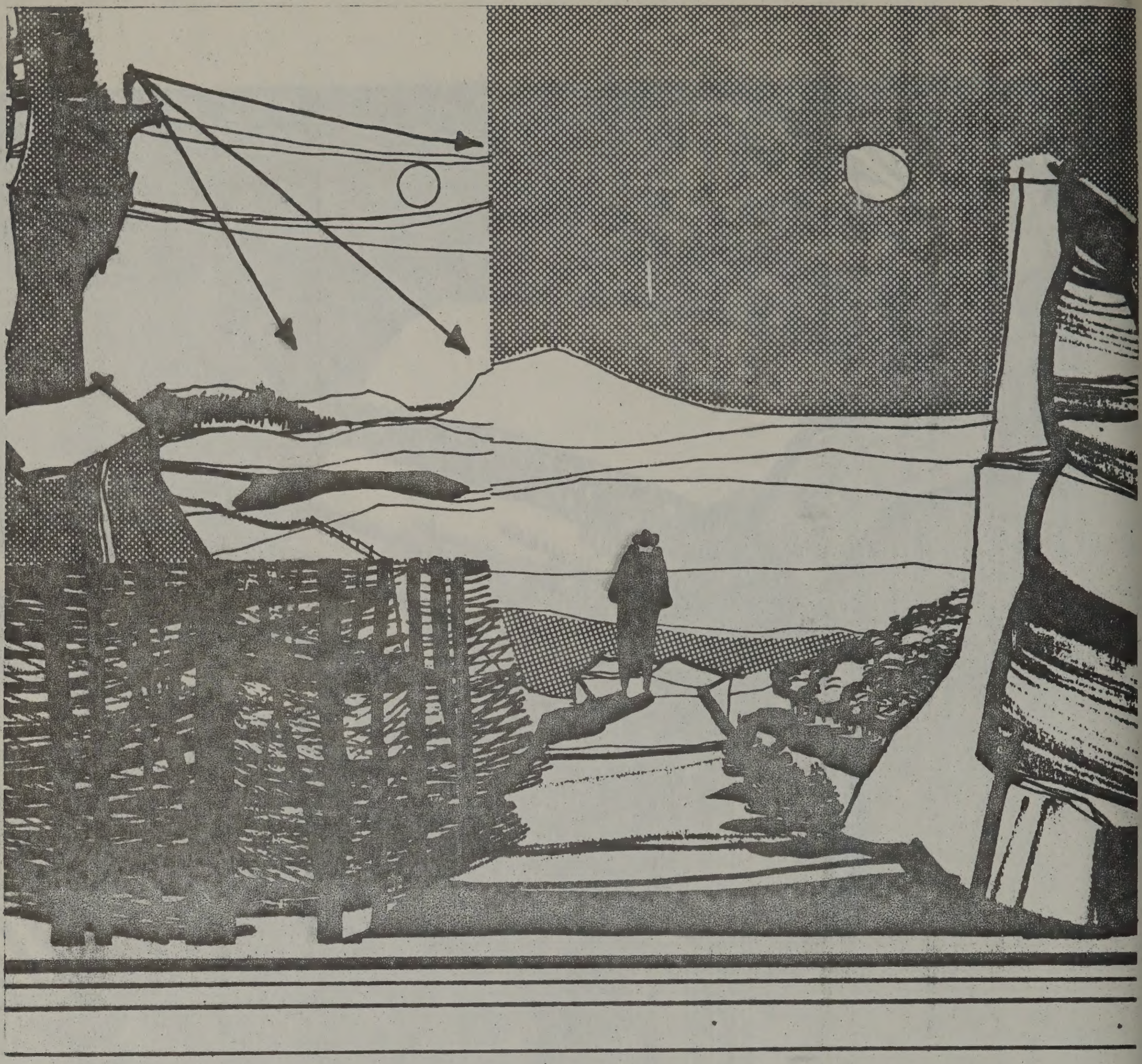


Fig. V.23

Standing on the rim, a man cannot help but admire the scenery below. He may even feel exalted with a feeling of superiority or have a sense of fear and danger to be viewing the panorama from such a high vantage point.

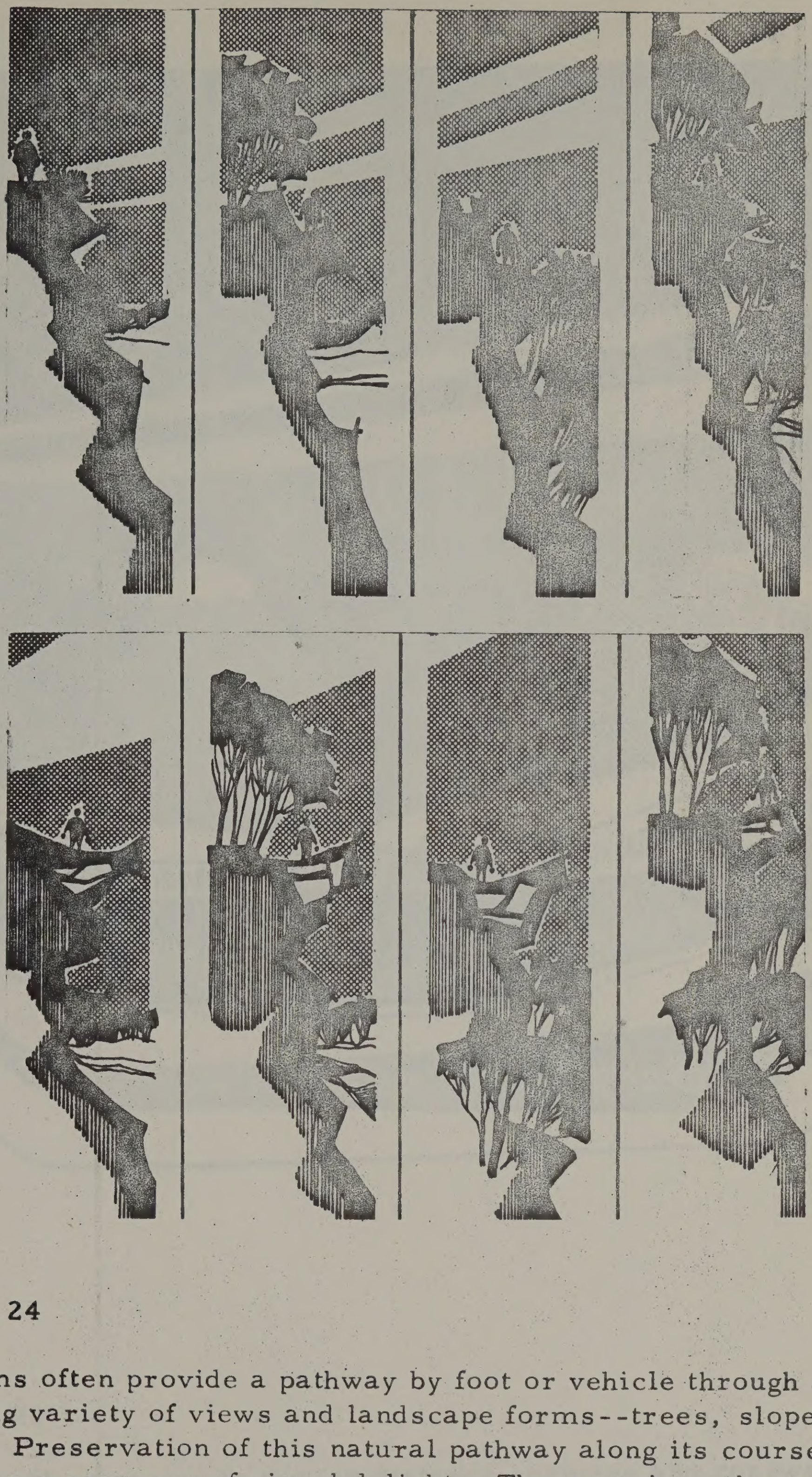


Fig. V.24

The rims often provide a pathway by foot or vehicle through an ever-changing variety of views and landscape forms--trees, slopes and rocks. Preservation of this natural pathway along its course will allow for a sequence of visual delight. These various characteristics can be classified. In one place along the rim one may find bare rock, in another place trees below, all constituting a series of situations that provide a variety of experiences.

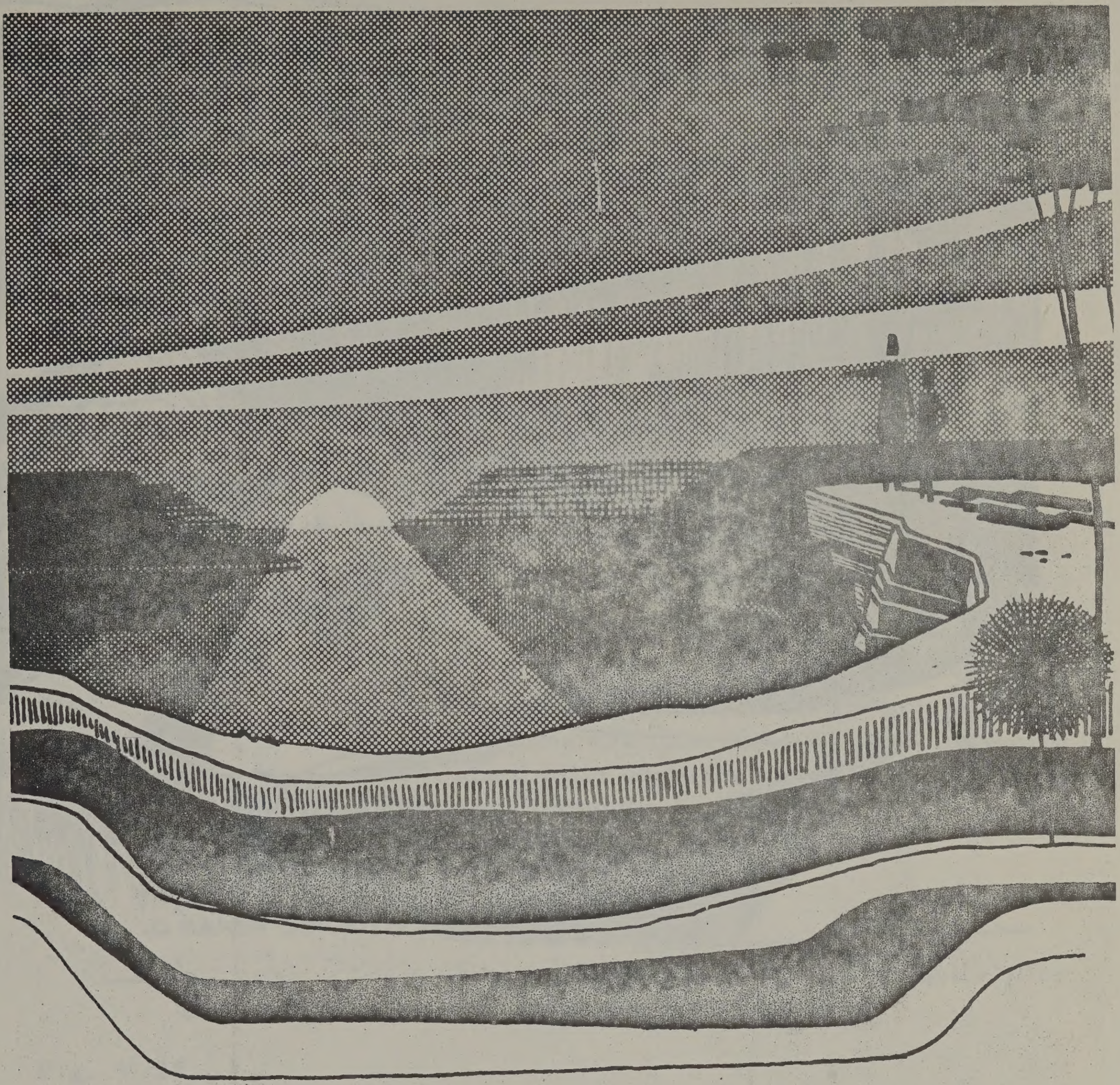


Fig. V.26

The visual extension to the far distance restores and renews man's spirit and strength in the calm and stability of the landscape and skyscape--perhaps a view of the rising and setting of the sun or moon.

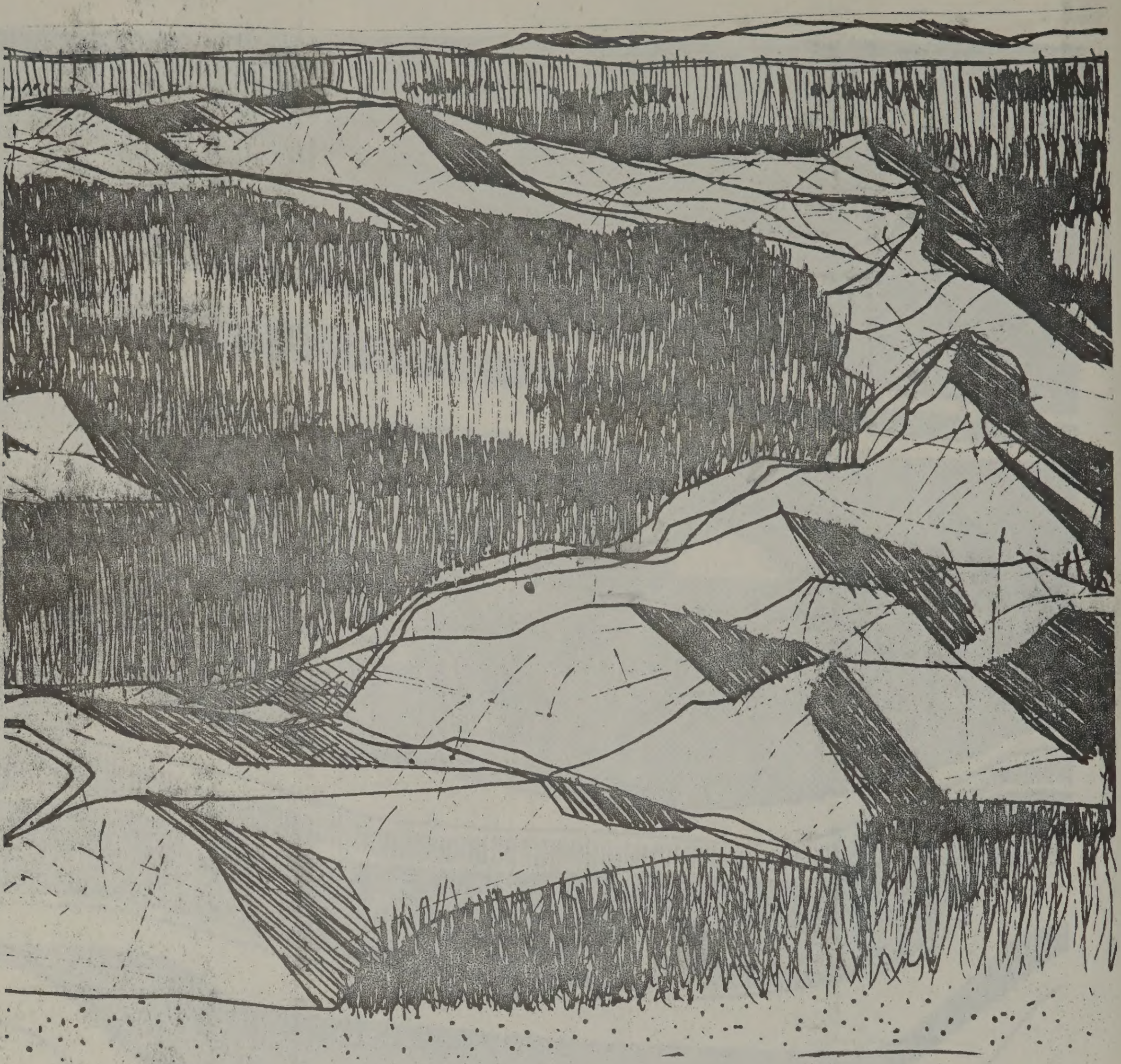
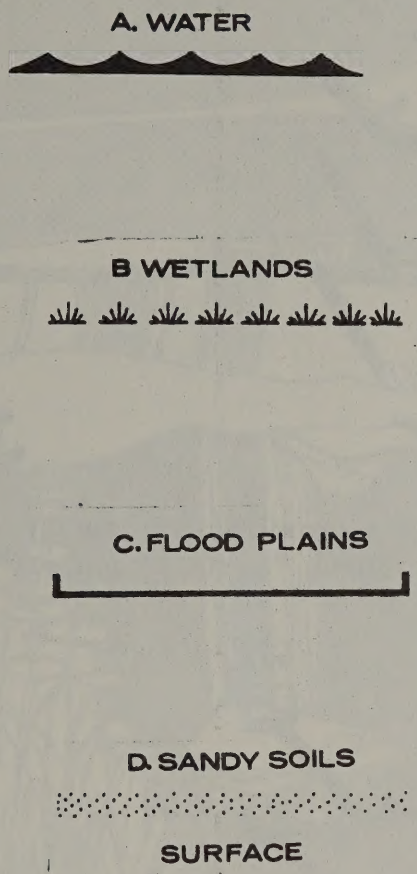


Fig. V.27

Land form corridors result from a combination of "slopes" and "rims" that produce a ridge or land form corridor.

Water-wetland corridors are the second major form of environmental corridor.



Kept clean, water offers vast acreages of resource quality and open space.

Headwater marshes, wildlife habitat, sources of natural springs and aquifer recharge patterns produce wetlands.

Exceptional recreational and open space systems are offered by floor plains which offer little opportunity for safe man-made development.

When adjacent to water, sandy soils offer outstanding swimming areas.

Fig. V.28

These "surface patterns" of water, wetlands, flood plains and sandy soils adjacent to water are in many cases enclosed by varying degrees of "slope."

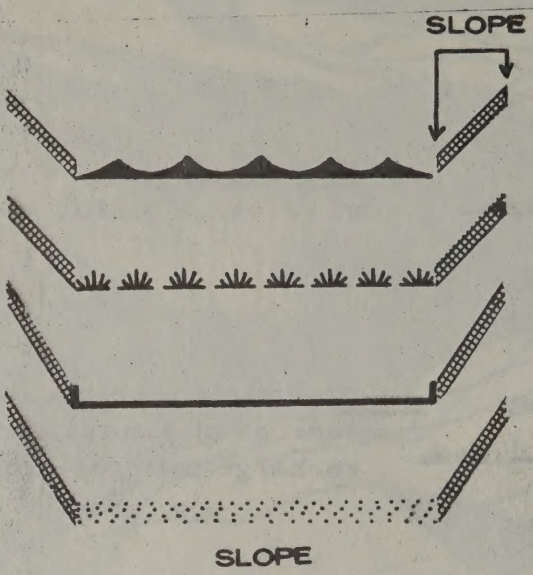


Fig. V.29

Since slope is subject to various degrees of erosion, they should be stabilized to prevent silting and pollution of the "surface" pattern below.

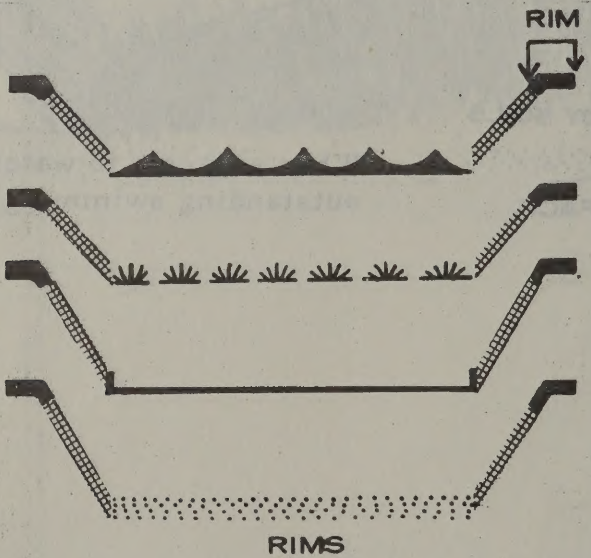


Fig. V.30

The "rims" of "slope" offer the best advantage spot from which to observe and contemplate the "surface" resources below. The rims also offer suitable traversing strips for bridle, hiking and bicycle trails or parkways.

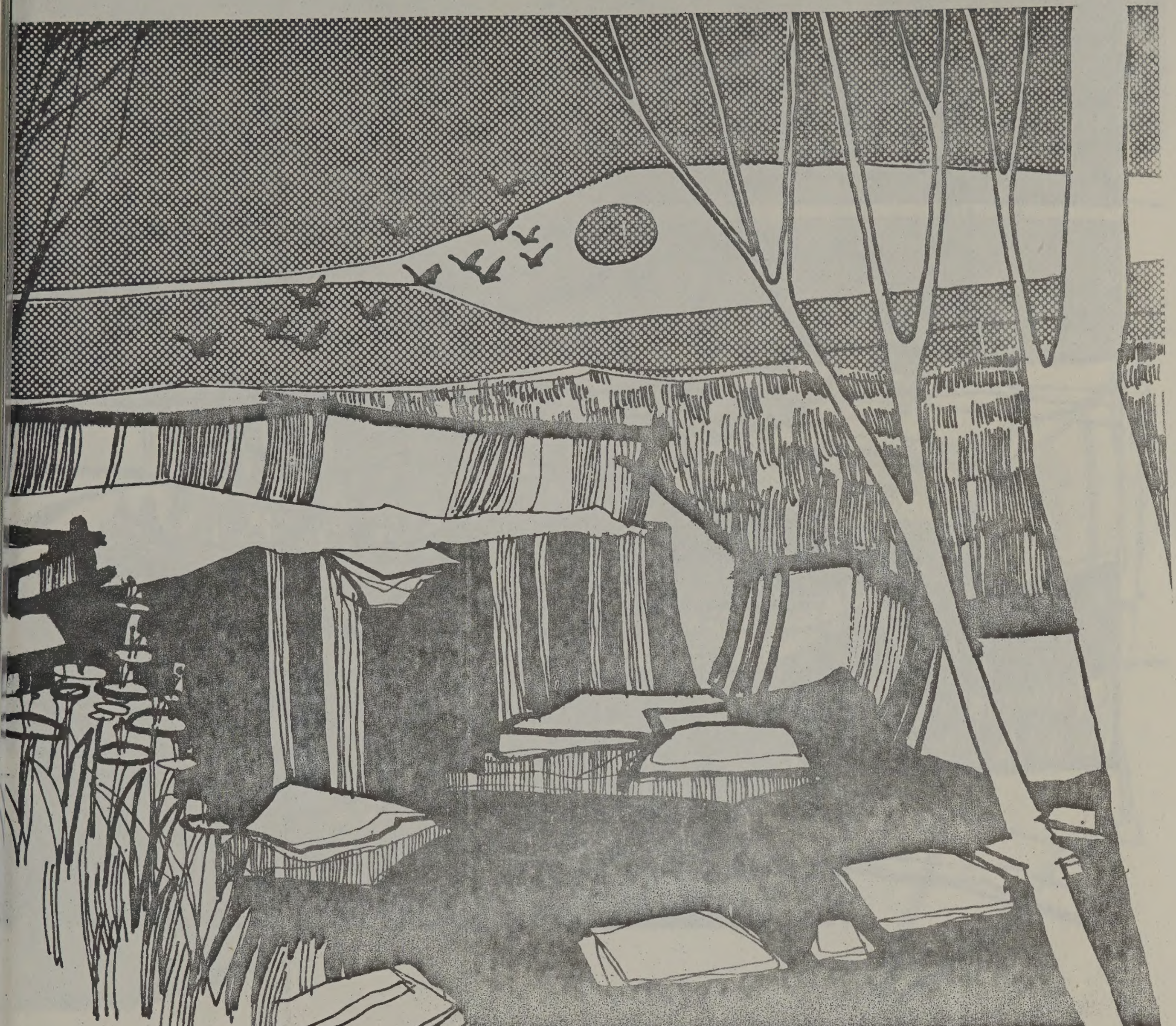


Fig. V.31

In the streams run the sparkling clarity of clean, rushing water accompanied by refreshing sounds of nature. Spoilage of the streams by careless use destroys these regional habitats for the fish and the sport of the fisherman.

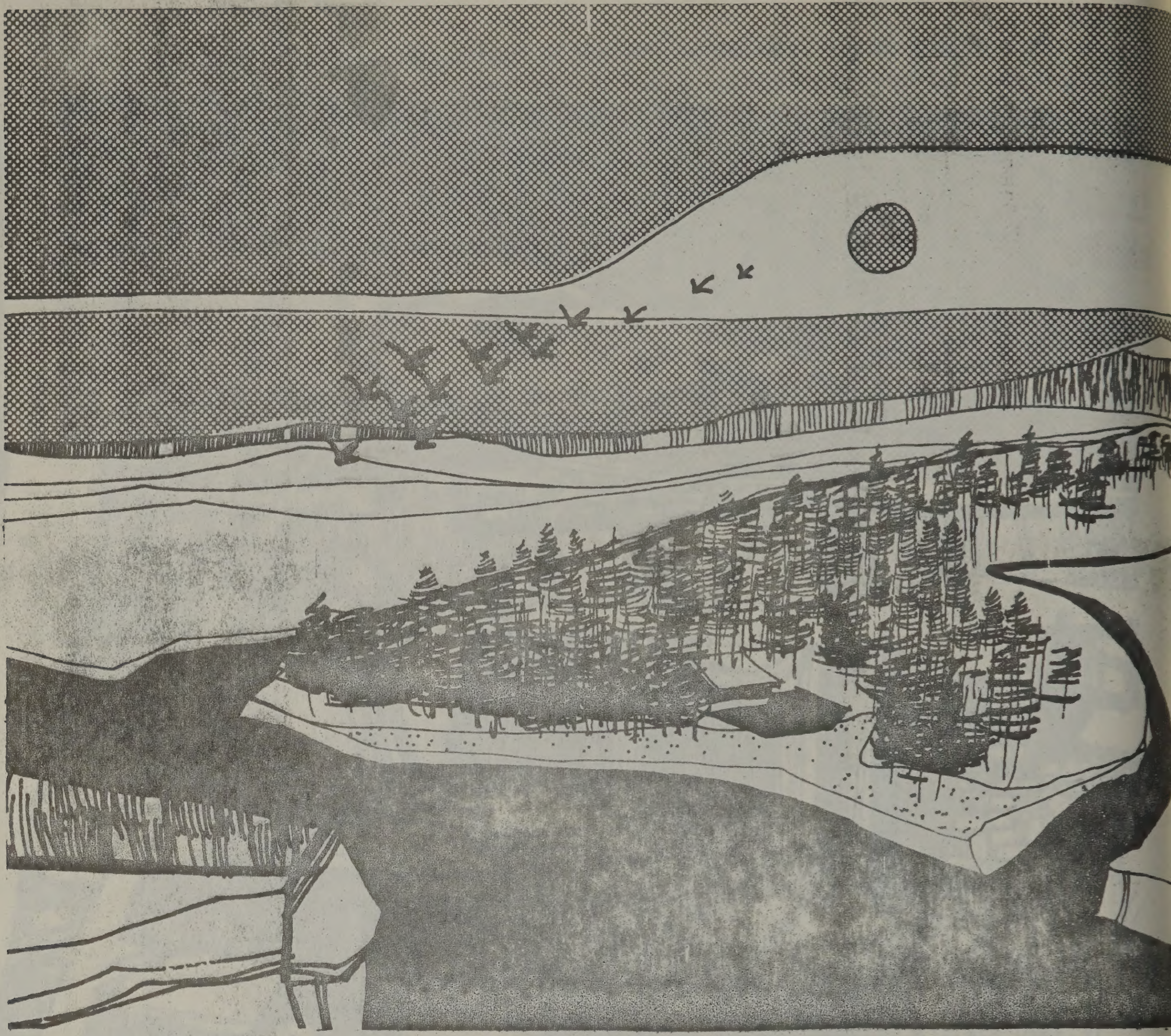


Fig. V.32

At the end of the stream is the river. The flowing river is filled with life and movement and helps serve as a mirror of the world around. A river is a resource to be viewed from above and below and whose entire course should be developed wisely for future generations.

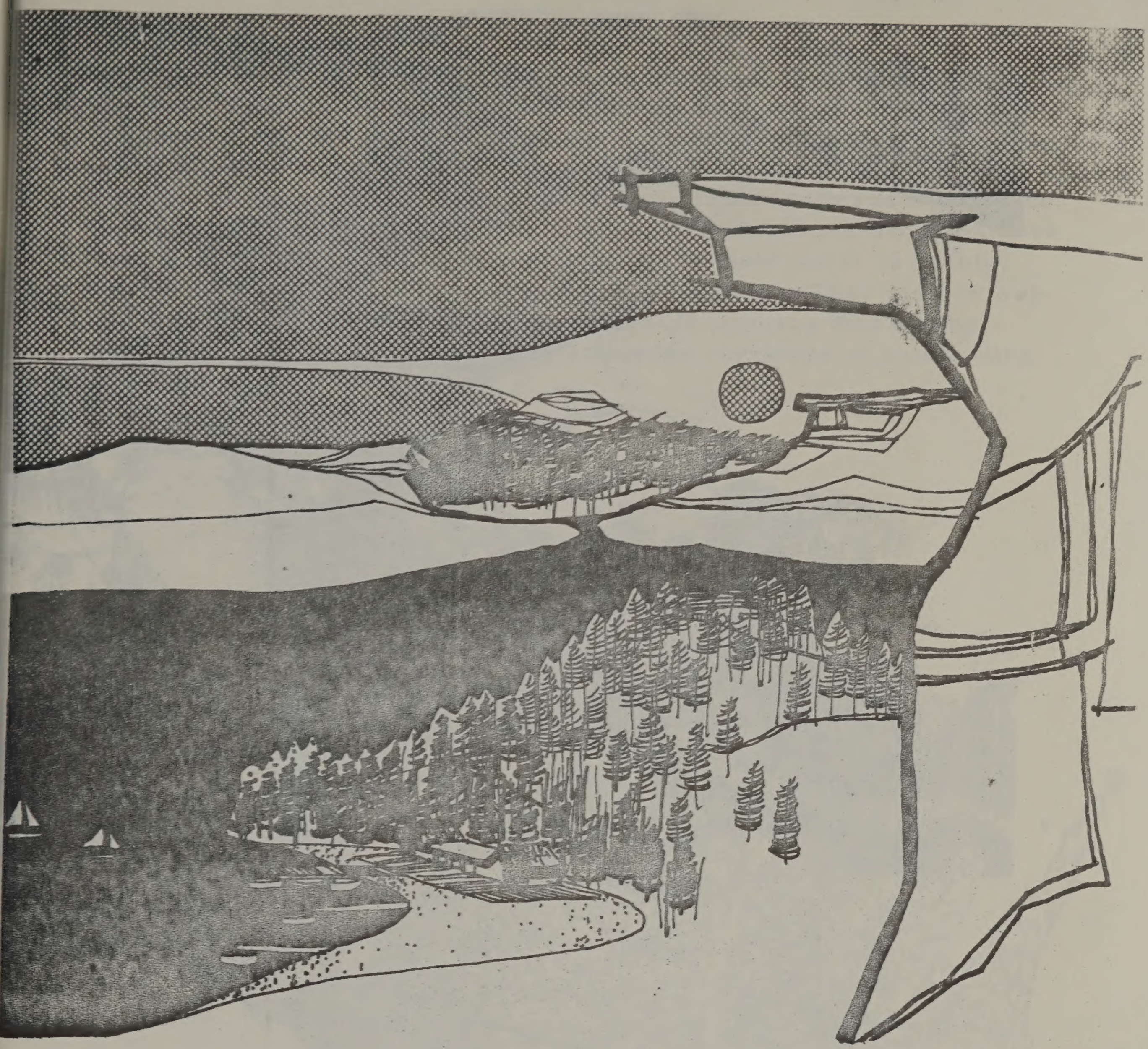


Fig. V.33

In many landscapes, the springs, streams, and rivers may discharge their water into the low flat regional formations called lakes. Lakes provide a storage area for water, a recreation facility of great diversity--boating, swimming, fishing, ice skating, and a mirror for quiet reflection and inspiration.

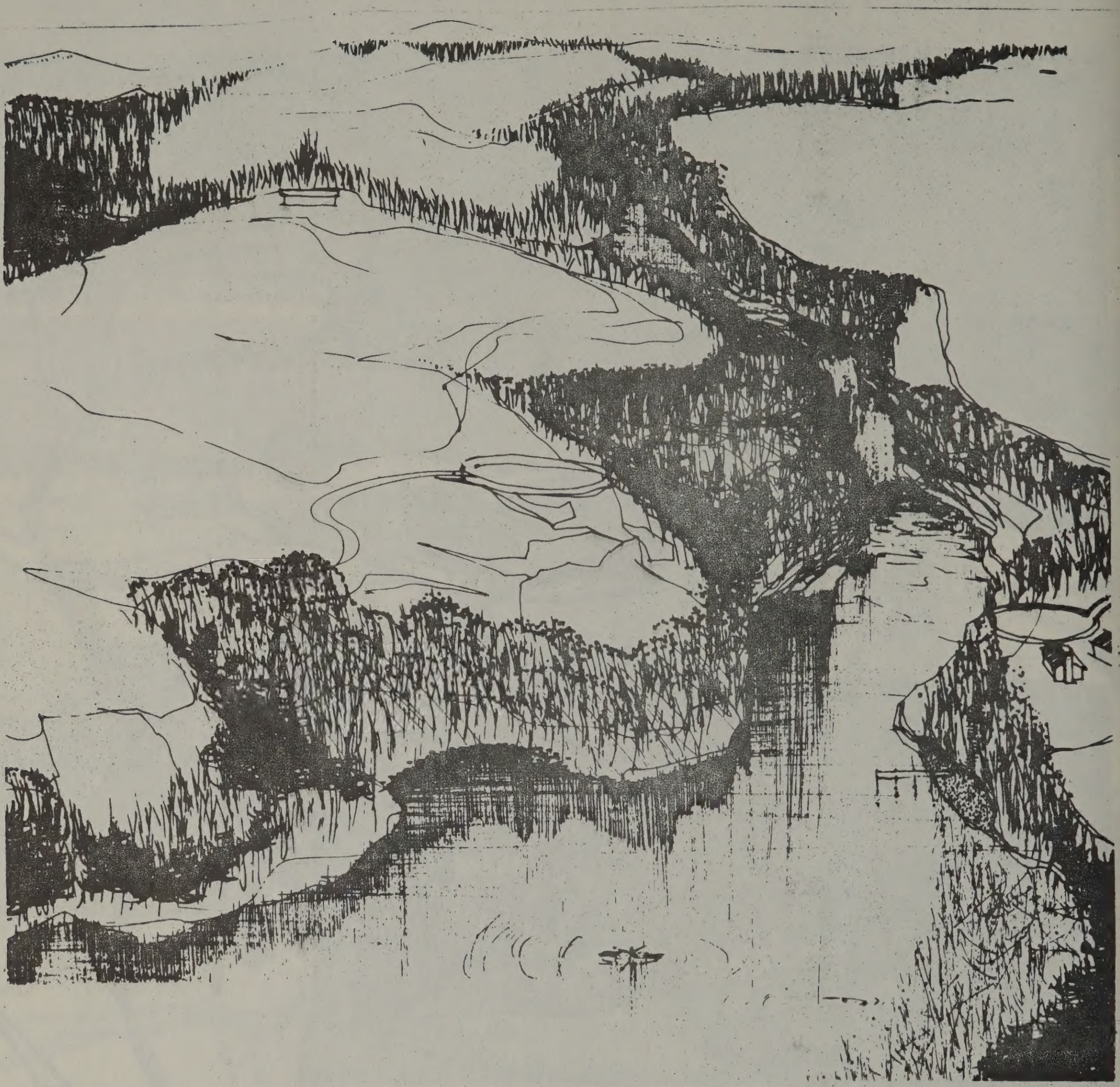


Fig. V. 34

Water-Oriented Corridor: A birds-eye view of the landscape quickly identifies the significant patterns or corridors found along rivers, flood plains and wetlands.

Statewide environmental corridors were plotted in Wisconsin under that state's $50 million Outdoor Recreation Act. From this study, it is apparent that the extensive landscape resources of water, wetlands and significant topography created by wind, water and glacial action through the ages have etched predominantly linear patterns on the face of the Wisconsin landscape. The flat, rolling farmlands and expansive forest patterns between these corridors have their share of beauty, but it is the bluffs, ridges, roaring and quiet waters, and mellow wetlands and sandy soils combining in elongated patterns that tie the landscape together in regional and statewide corridors of outstanding landscape quality.

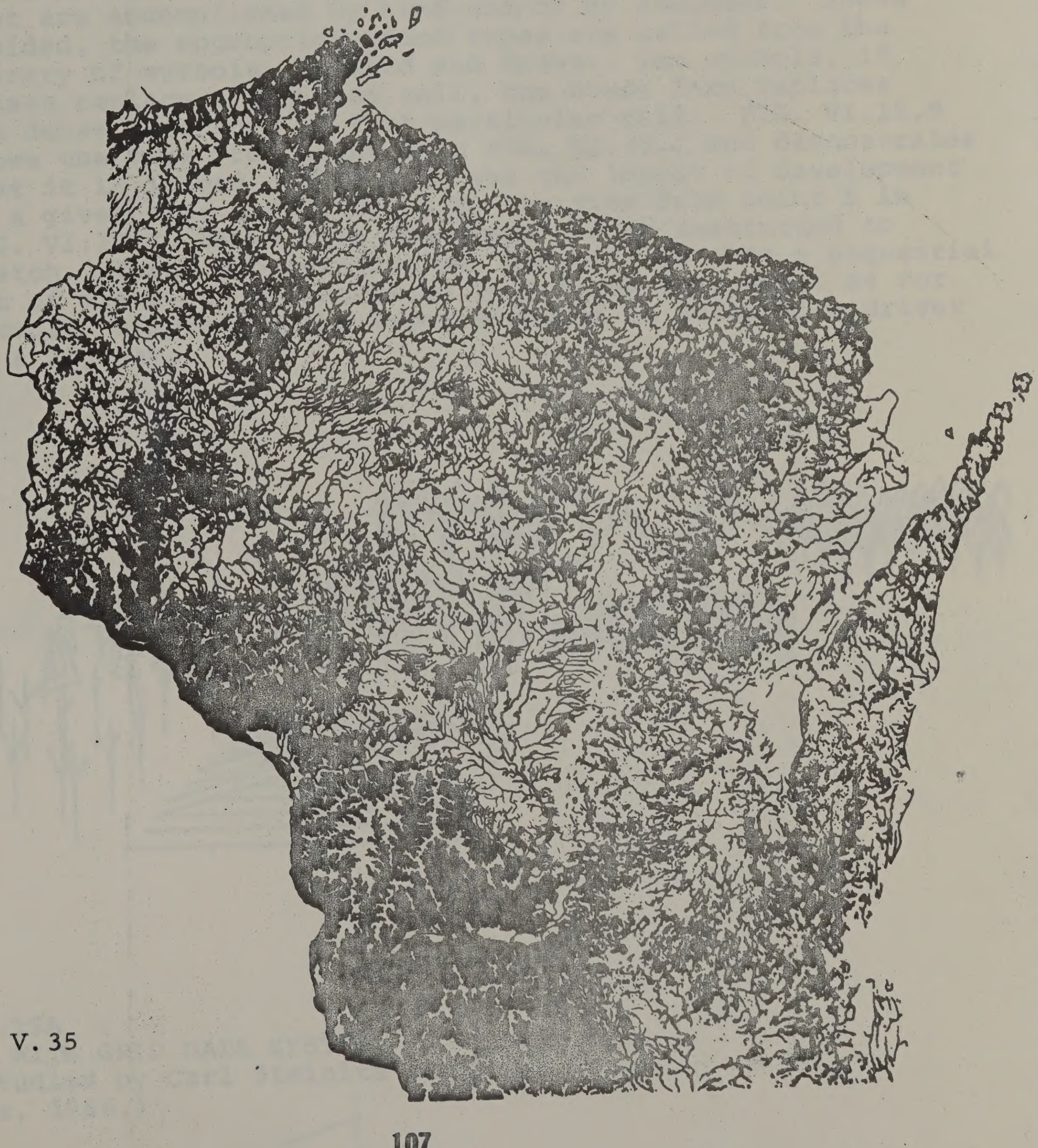


Fig. V. 35

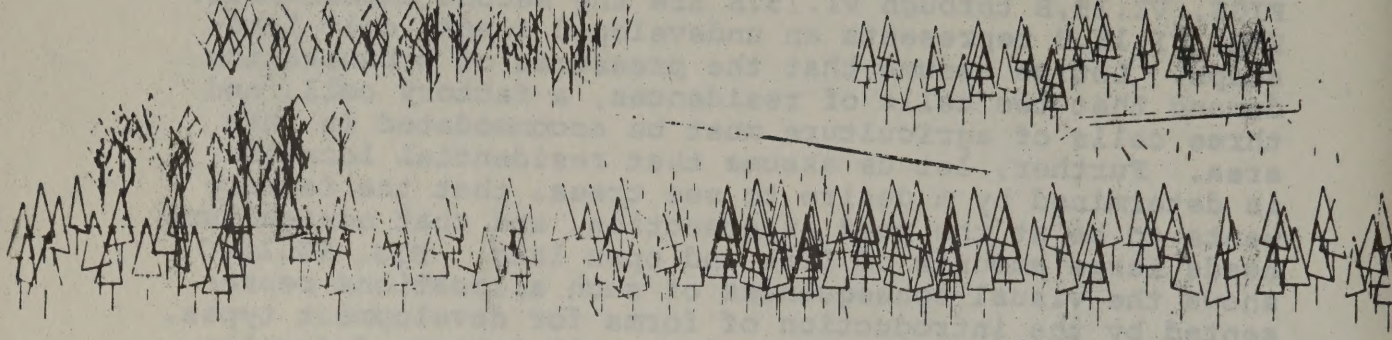


FIG. VI.15B

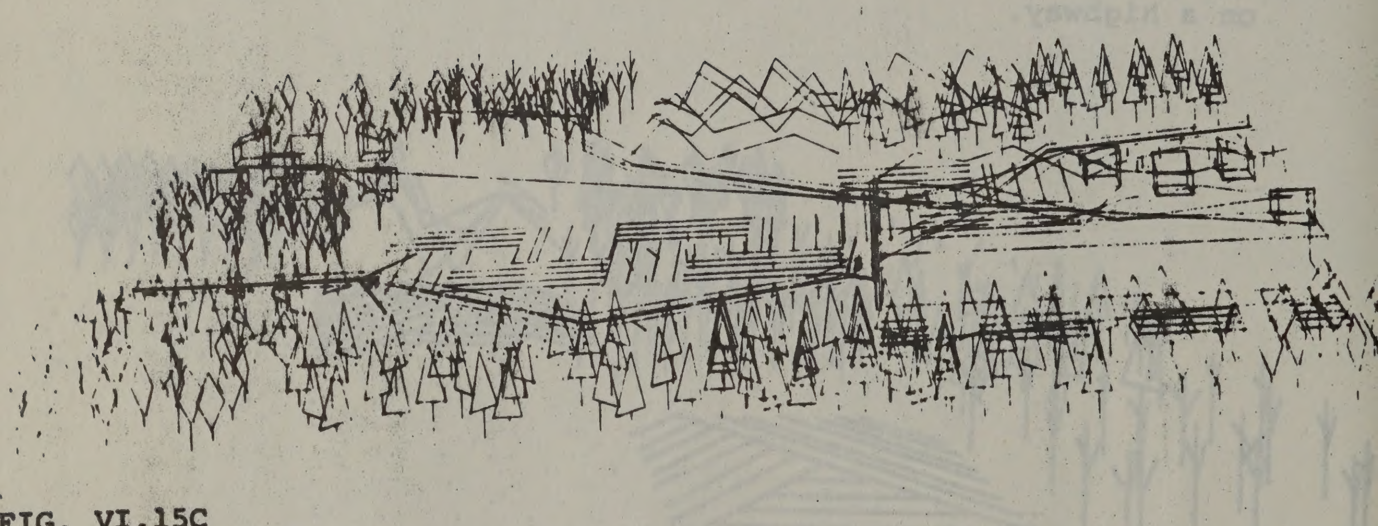


FIG. VI.15C

An earlier study of Illinois and more recent studies of the Upper Mississippi Valley and the Great Lakes Basin have demonstrated that most of the outstanding natural and cultural diversity lies within these land and water-wetland corridors. Individual states must deal with private ownership in protecting values important to their citizens. The task of protecting comparable values on public lands should be much easier.

Environmental Corridors

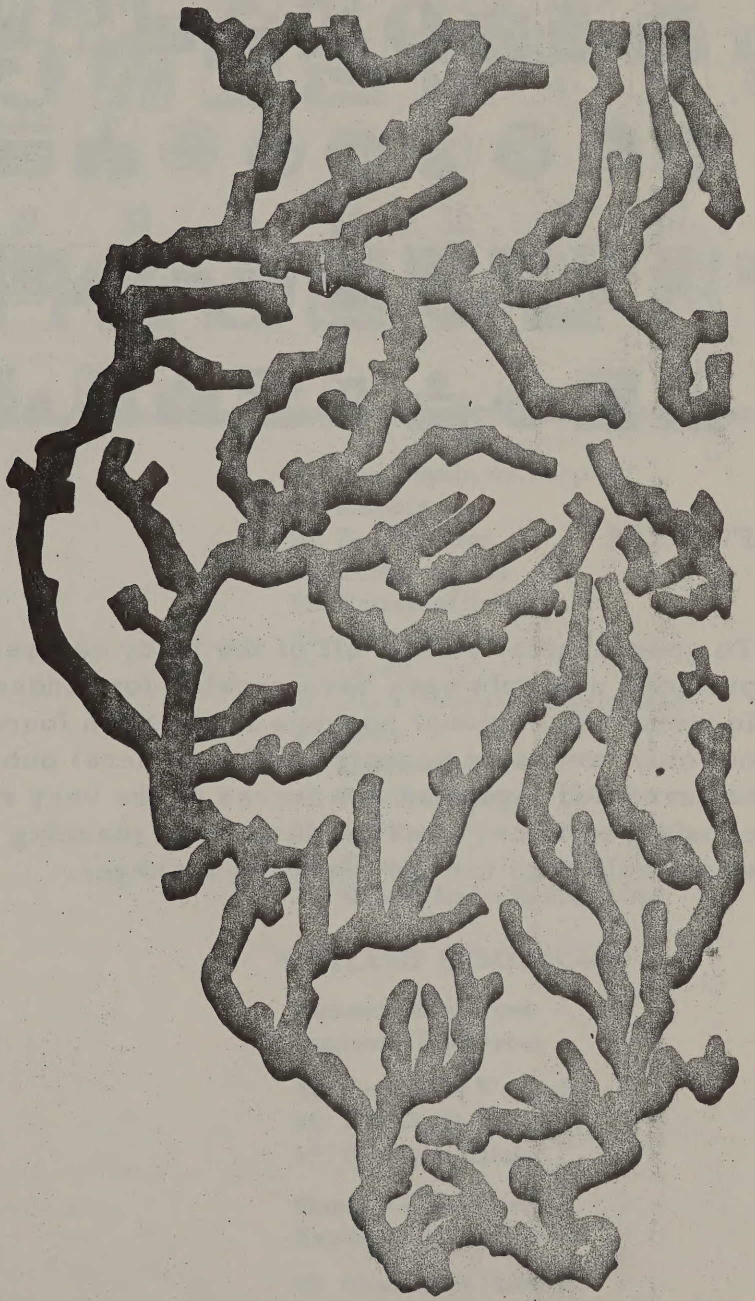


Fig. V. 37

Natural and Cultural Value Patterns

Besides the corridor resources the State of Wisconsin study provided an opportunity to identify many additional natural and cultural features in the landscape that were held in high esteem by the public as major environmental value patterns. Unlike corridor patterns which thread through the landscape, most of these supplementary resources have been found to occupy specific sites.

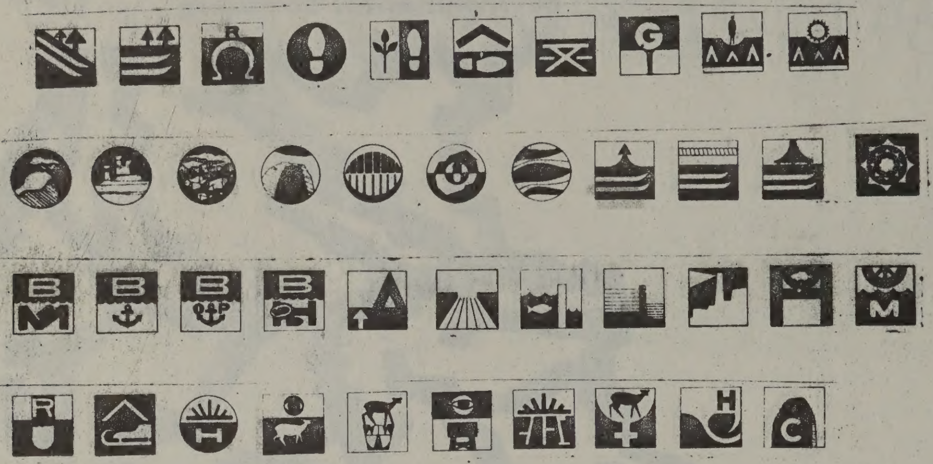
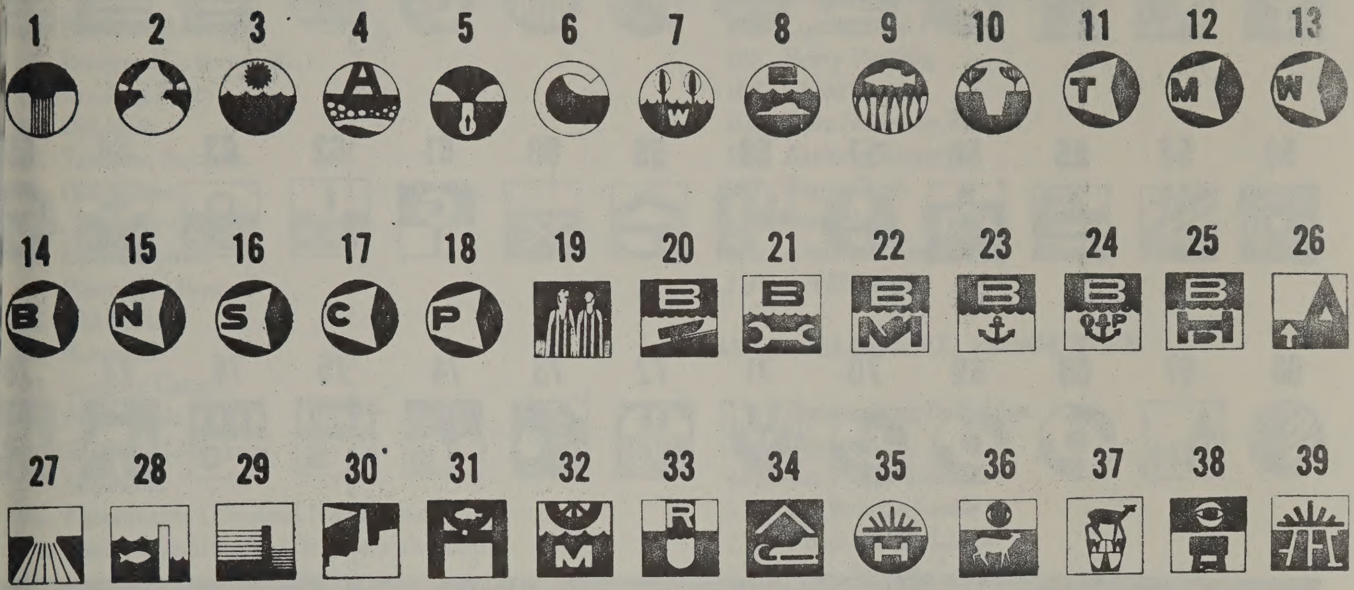


Fig. V. 38

To geographically show all of the many natural features on public lands, pictorial symbols have been created for landscape survey mapping use. In numerous regional surveys it has been found that the symbols were not only favorably accepted by the general public, but that they also fostered and expanded awareness of the very resources that must be considered in any sensible landscape planning program. The same would hold true for the resource manager.

Recreation Resource Symbols Used in Wisconsin



WATER RESOURCES

Natural Resources
Intrinsic Resources

1. Waterfalls
2. Rapids, Whitewater
3. Bathing Beaches
4. Agate Beaches
5. Natural Springs, Artesian Flows
6. Canoe Routes
7. Wild Rice Areas
8. Exceptional Islands
9. Fish Habitat
10. Chasms
11. Trout
12. Muskellunge
13. Walleye
14. Bass
15. Northern Pike
16. Sturgeon
17. Catfish
18. Panfish

Manmade Facilities
Extrinsic Resources

19. Swimming Facilities
20. Boating Facilities, Ramps
21. Fuel, Repair, and Supplies
22. Marinas
23. Boating Areas
24. Outfitting Posts
25. Harbors of Refuge
26. Campsites
27. Canals
28. Dams, Fishways, Drainage Ways
29. Locks
30. Lighthouses
31. Fish Hatcheries
32. Mill Ponds
33. Reservoirs
34. Shelters for Ice Skating Areas

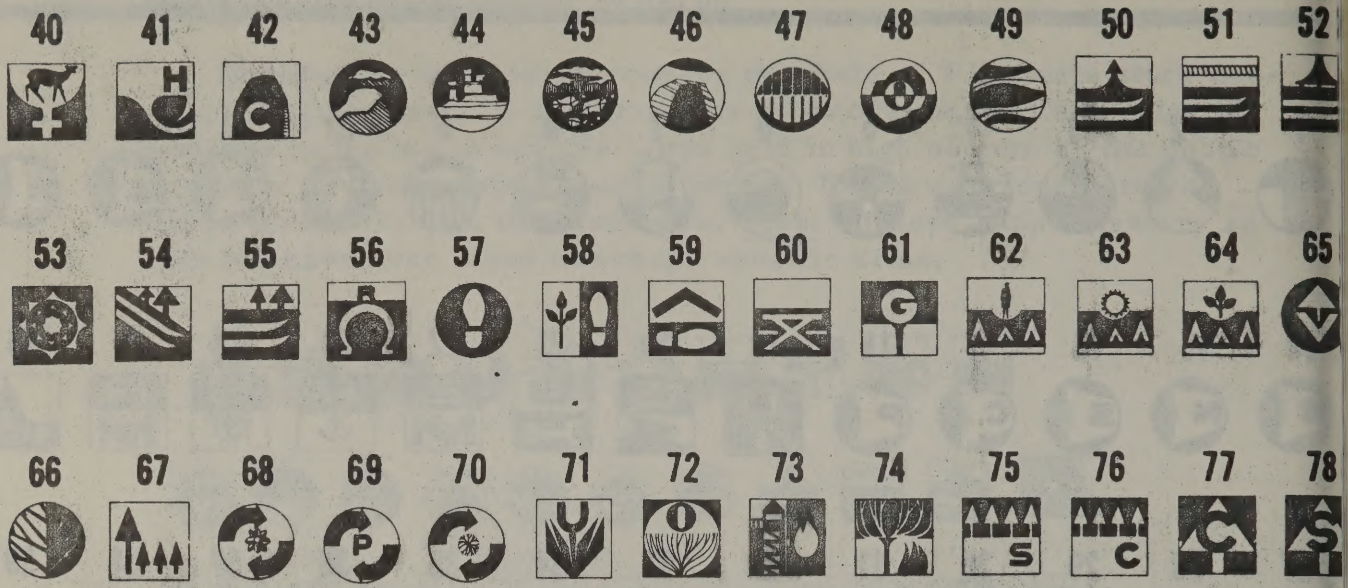
WETLAND RESOURCES

Natural Resources
Intrinsic Resources

35. Exceptional Wetlands
36. Wildlife Observation
37. Wildlife Hunting

Manmade Resources
Extrinsic Resources

38. Observation Platforms
39. Wetland Projects, Levees, Ditching and Diking



40. Wildlife Preserves
41. Hunting Preserves

TOPOGRAPHIC RESOURCES

Natural Values

(Unique Geological Formations)
42. Caves
43. Balanced Rocks
44. Castle Rocks
45. Exceptional Glacial Remains
46. Natural Bridges
47. Stones and Fossil Collection Areas
48. Mineral Ore Outcroppings
49. Outstanding Soil Conservation Projects—also farm conservation

Manmade Values

50. Ski Lifts
51. Ski Rope Tows
52. Ski Slope Structures
53. Snow Play Areas, Sledding, etc.
54. Ski Trails
55. Ski—(Cross Country)
56. Riding
57. Hiking
58. Nature Trails
59. Trail Shelters
60. Picnic Areas
61. Golf Courses
62. Youth Camps
63. Nature Camps
64. Day Camps

VEGETATION RESOURCES

Natural Resources

65. Virgin Stands (Timber)
66. Rare Remnants
67. Outstanding Reforestation Projects
68. Wildflowers
69. Prairies
70. Specimens (Trees, etc.)
71. Unusual Crops
72. Orchards
73. Fire Towers
74. Fire Trails and Breaks

Manmade Resources

75. State Forests (Existing Potential)
76. County Forests (Existing Potential)
77. County Parks (Existing Potential)
78. State Parks (Existing Potential)

79. State Recreation Areas (Existing Potential)

HISTORICAL AND CULTURAL RESOURCES

Manmade Resources

80. Blacksmith Shops
81. Bridges (Covered, etc.)
82. Trading Posts
83. Old Mills
84. Taverns, Saloons
85. Old Mines
85A. Pioneer Church
86. Opera Houses
87. Historical Homes
88. Old Forts
89. Barracks
90. Lumber Camps
91. Battlefields
92. Historical Markers
93. Museums
94. Restaurants (Unusual Native Dishes)
95. Native Handicrafts (Draftsmen's Shop)
96. Local Festivals, Celebrations
97. Outstanding Farmers Markets
98. Modern Mines
99. Power Plants
100. Modern Mills
101. Interesting Industries Open for Visits
102. Commercial Fishing
103. Berry Picking
104. Ghost Towns
105. Rifle Shooting Ranges
106. Archery Ranges
107. Sugar Bush
108. Songbirds
109. Aesthetic Areas
110. Art Museums

ARCHEOLOGICAL RESOURCES

111. Outstanding Buildings
112. Theaters
113. Ex. Public Lands
114. Ex. Private Lands
115. Prop. Public Lands
116. Prop. Private Lands

79

80

81

82

83

84

85

85A

86

87

88

89

90

91

92

93

94

95

96

97

98

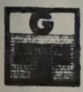
99

100

101

102

103

104

105

106

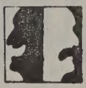
107

108

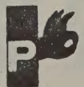
109

110

111

112

113

114

115

116

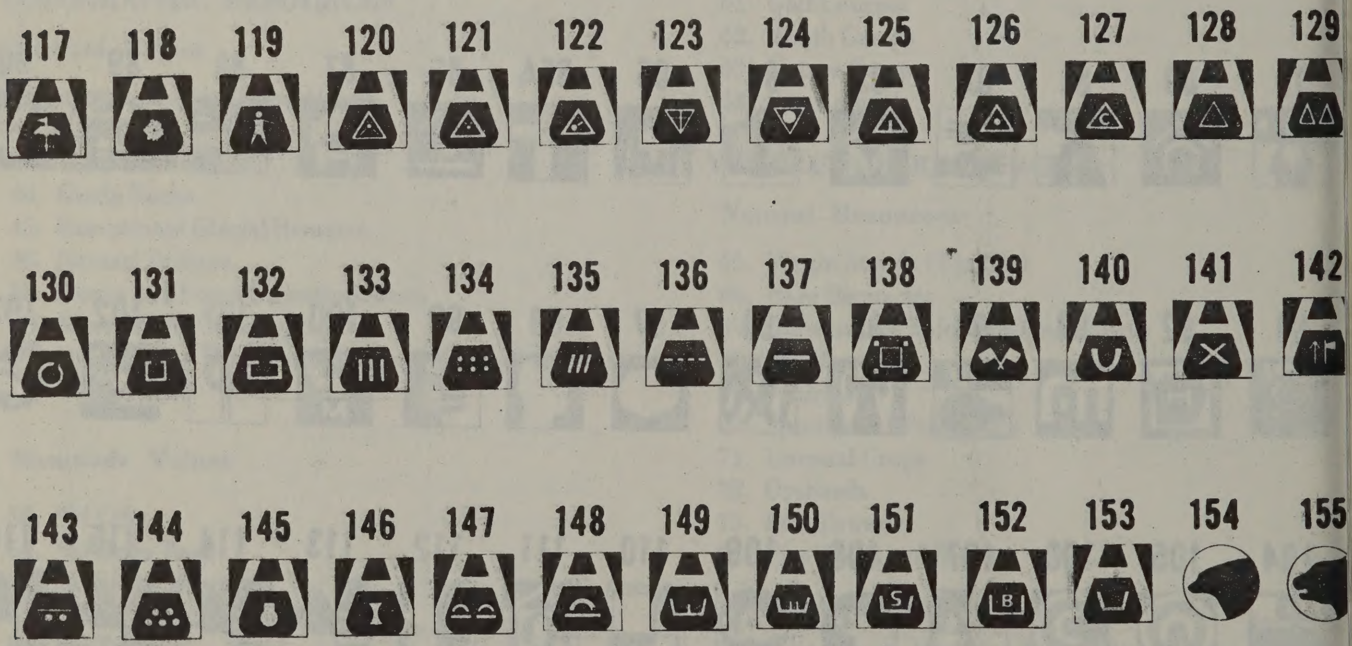
117. Effigy Mound
118. Sugar Bush
119. Petroglyph
120. Quartzite
121. Pipestone
122. Steatite
123. Quarry Flint
124. Copper
125. Lead
126. Quartz
127. Chlorite
128. Campsite
129. Village Site
130. Circular Enclosure
131. Square Enclosure
132. Rectangular Enclosure
133. Wild Rice
134. Cornfield
135. Garden Bed
136. Trail
137. Ford
138. Fort
139. Battlefield
140. Cache Pits
141. Workshop
142. Historic Village Sites
143. Provision Cache
144. Shell Heap
145. Ceramic Artifacts
146. Conical Mound
147. Mound Group
148. Mound—Round-Oval
149. Historic Cemetery
150. Prehistoric Cemetery
151. Stone Grave
152. Burial Ground
153. Grave

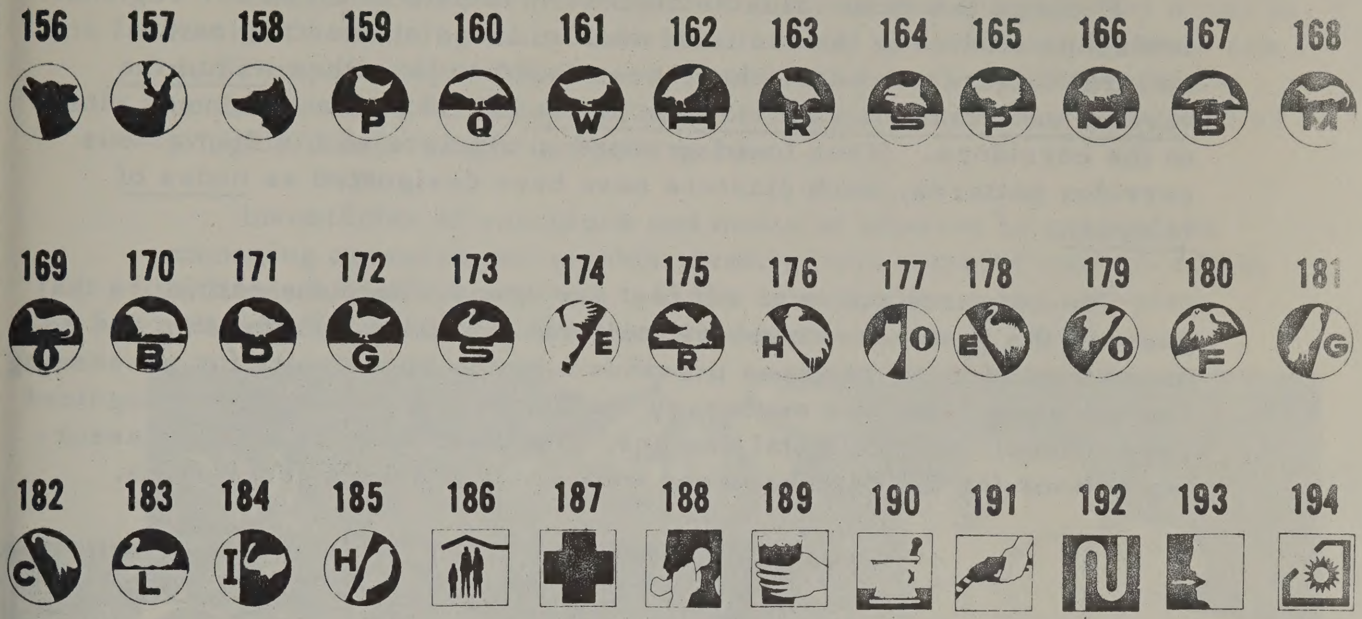
WILDLIFE

Natural Resources

BIG GAME

154. Bear
155. Bobcat





156. Wolf
157. Deer
158. Red & Grey Fox

SMALL GAME

159. Pheasant
160. Quail
161. Woodcock
162. Hungarian Partridge
163. Ruffed Grouse
164. Sharp-tailed Grouse
165. Prairie Chicken
166. Muskrat
167. Beaver
168. Mink
169. Otter
170. Badger

WATER FOWL

171. Ducks
172. Geese
173. Swans

BIRDS

174. Eagles
175. Red-tailed Hawks
176. Herons
177. Great-horned Owls
178. Egrets
179. Osprey
180. Falcons
181. Goshawks
182. Cranes
183. Loons
184. Ibis
185. Hawks

TOURIST SERVICE FACILITIES

186. Accommodations
187. Hospital
188. Telephone
189. Water
190. Pharmacies
191. Gas Stations
192. Toilet Facilities
193. Restaurant
194. Washer-Dryer

Fig. V. 39

Nodes of Interest Patterns

Perhaps the most valuable discovery to date in all of our regional landscape studies is the fact that most of these outstanding natural and cultural features or values have been found to lie either within the various environmental corridor patterns (85-90 percent) or very close to the corridors. When found grouped in clusters within the various corridor patterns, such clusters have been designated as nodes of interest.

The resource nodes of interest are areas within the corridors that possess the greatest natural and cultural diversity. Protection and enhancement of these patterns provides a better opportunity for possessing resource combinations necessary for future and currently unrecognized recreational environmental designs. They are key patterns for assuring options for the happiness and well-being of future generations.

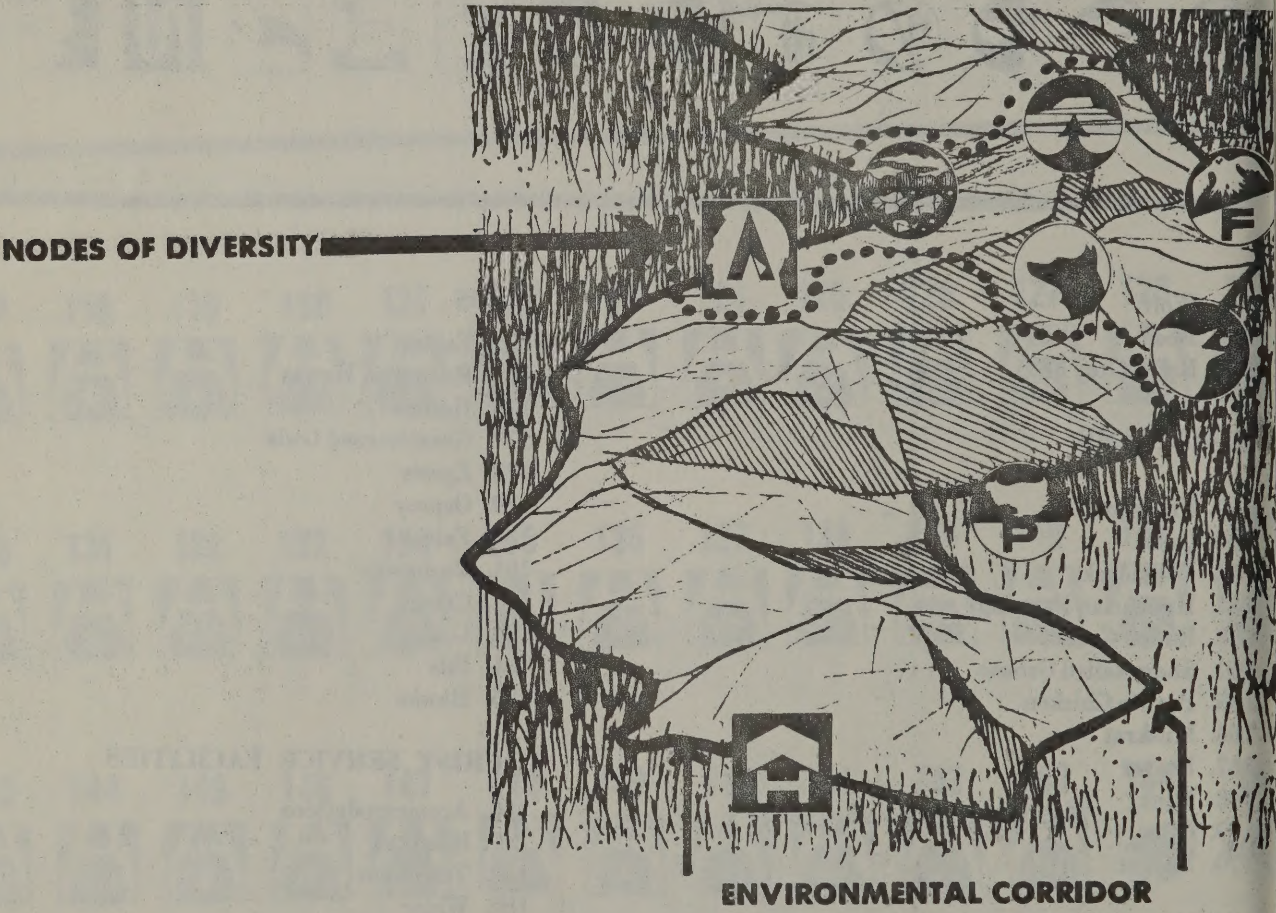
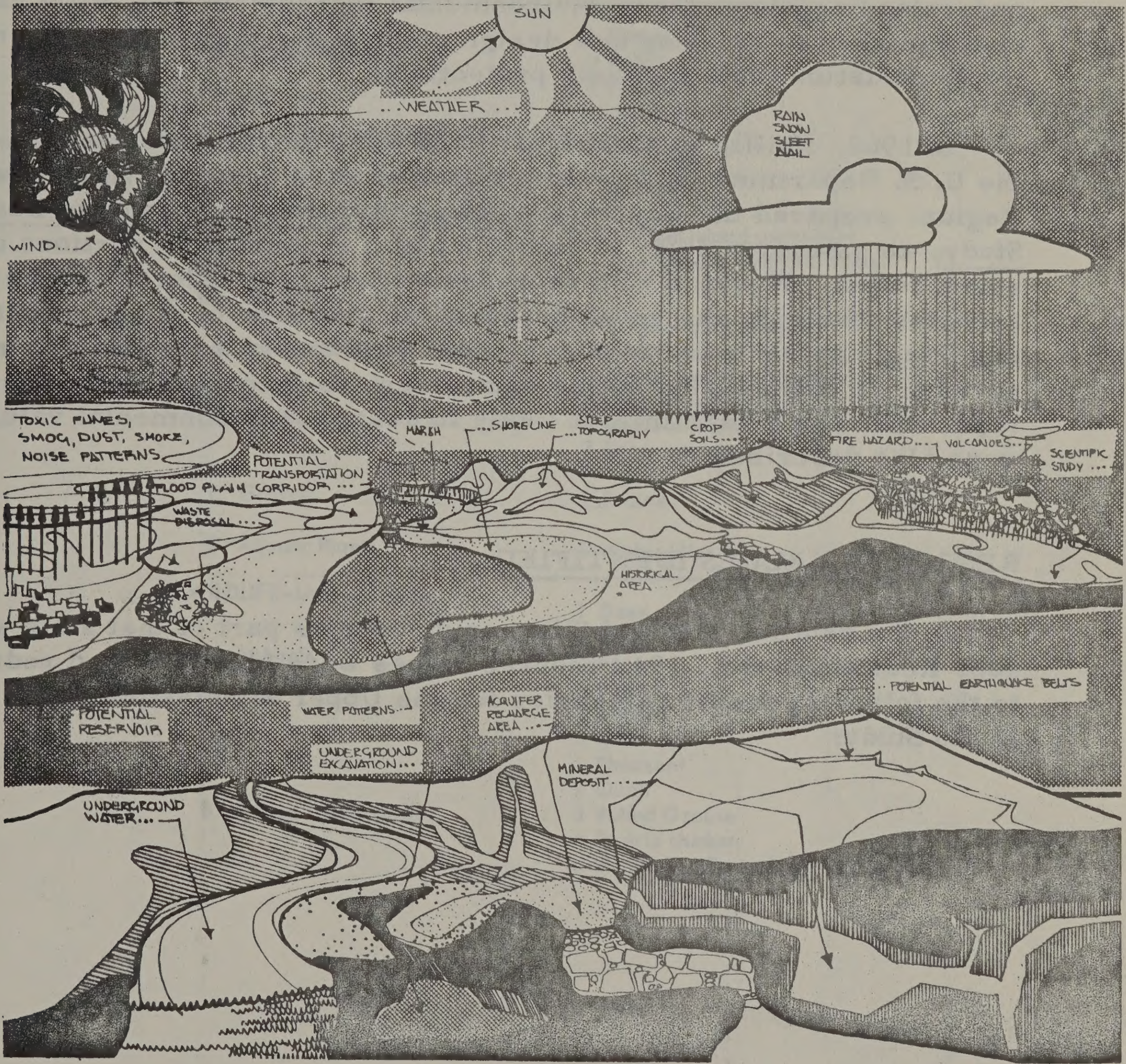


Fig. V.40

Based upon subjective conclusions, one can suggest that nodes of interest containing many individual natural and cultural features are more important than those areas with one or two. This judgment could be modified, however, if one single resource was identified as a highly unique single-purpose value.

Inventories of corridors and nodes of interest by public land managing agencies can quickly identify 'concentrated quality' within millions of open land acres. In the next chapter a step-by-step procedure for such inventories is explained.


SUN
...WEATHER...
RAIN
SNOW
SLEET
HAIL
WIND...
TOXIC FUMES, SMOG, DUST, SMOKE, NOISE PATTERNS
MARSH
...SHORELINE
STEEP ...TOPOGRAPHY
CROP SOILS...
FIRE HAZARD...
VOLCANOES...
SCIENTIFIC STUDY...
POTENTIAL TRANSPORTATION CORRIDOR...
FLOOD PLAIN
WASTE DISPOSAL...
HISTORICAL AREA...
...POTENTIAL EARTHQUAKE BELTS
POTENTIAL RESERVOIR
WATER PATTERNS...
ACQUIFER RECHARGE AREA...
UNDERGROUND EXCAVATION...
MINERAL DEPOSIT...
UNDERGROUND WATER...

GRAPHIC SUMMARY OF FORM DETERMINANT PATTERNS

Fig. V.41

Chapter VI.

STEP-BY-STEP DEMONSTRATION OF FIRST APPROXIMATION INVENTORY

It is easy to talk about environments in generalities, but the task of protecting and enhancing the remaining attributes that provide diversity requires, in the first place, the task of identifying, evaluating and locating the attributes in the real, living landscape. Without understanding where these environmental ingredients are, little can be accomplished in creating new design criteria for their enhancement or implementation tools for their protection.

In 1969, Phillip H. Lewis, Jr. and Associates, under auspices of the U. S. Department of Interior, National Park Service, Northeast Region, prepared the Upper Mississippi River Comprehensive Basin Study, an extensive study of environmental resources in portions of seven states. Working with representatives of the federal and state agencies involved, the group produced an overview of the most outstanding "single value" and "corridor-node" patterns in a limited six-month survey. In this approximation study, serious threats to these resources, represented by human impact likely to destroy environmental values, were also described.

RESOURCE VALUES IDENTIFIED

In the detailed study of Wisconsin, done as part of that state's Outdoor Recreation Act, 194 resource values were identified and reduced to the following major categories for the Upper Mississippi River Basin Study:

1. WATER AND ITS ENVIRONS	
A. Water in Motion	1 Waterfalls
	2 Rapids
	3 White water streams
	4 Natural springs
B. Beaches	1 Agate
C. Wetlands (significant visually)	1 Marshes
2. LAND FORMS	
A. Rock Formations	1 Balanced rocks
	2 Castle rocks
	3 Natural bridges
	4 Unusual outcroppings
B. Glacial Remains	1 Kames
	2 Eskers
	3 Potholes
	4 Moraines
C. Underground Caverns	1 Caves
	2 Sinkholes
D. Interesting Topography	1 Chasms
	2 Canyons
	3 Unusual island complexes or islands over 10 acres
3. VEGETATION	
A. Trees and Shrubs	1 Virgin stands (timber)
	2 Rare remnants
	3 Flowering—major orchards
	4 Unusual fall color
B. Wildflowers	1 Unusual masses or fields
	2 Rare remnants
C. Grasses	1 Prairies
D. Aquatic Plants	1 Water lilies
4. WILDLIFE—Unique Habitat	
A. Animals	1 Deer
	2 Bear
	3 Fox
	4 Beaver
	5 Muskrat
	6 Otter
B. Upland Game Birds	1 Pheasant
	2 Quail
	3 Ruffed Grouse
	4 Prairie chicken
	5 Hungarian Partridge

C. Birds of Prey	1 Eagles
	2 Hawks
	3 Owls
	4 Falcons
D. Songbirds	1 Numerous
E. Water Birds	1 Herons
	2 Egrets
	3 Ospreys
	4 Cranes
	5 Loons
	6 Ibis
	7 Ducks
	8 Geese
	9 Swans

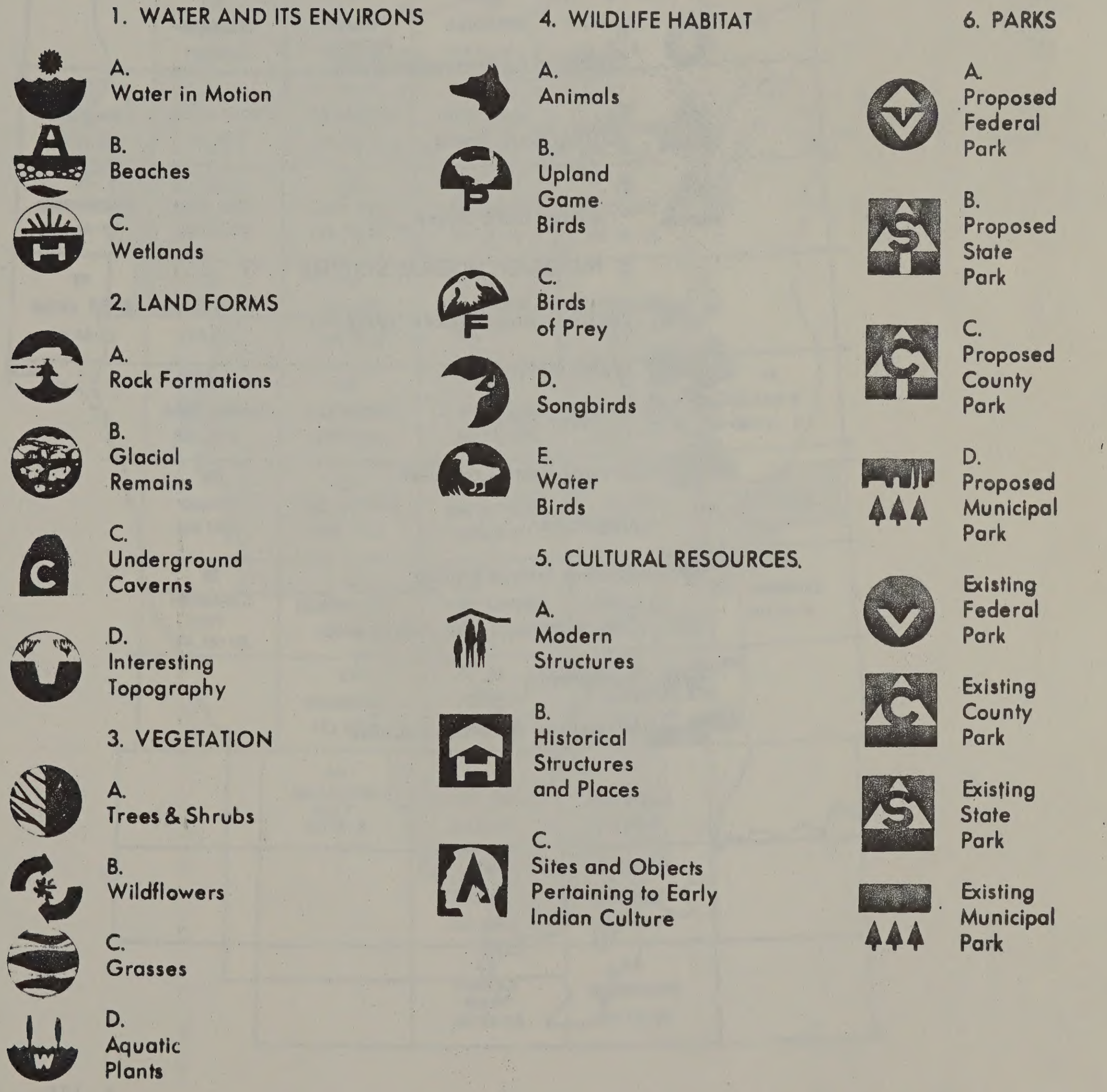
5. CULTURAL RESOURCES

A. Modern	1 Outstanding architectural bldgs.
	2 Bridges
(list each festival)	3 Outstanding local festivals
	4 Exceptional gardens
	5 Museums/Art galleries
B. Historical Structures & Places	1 Historical markers
	2 Lumber camps
	3 Forts
	4 Covered bridges
	5 Hills
	6 Trading posts
	7 Battlefields
	8 Homes
	9 Ghost towns
	10 Taverns
	11 Old mines
	12 Historical trails—land & water
	13 Canals and locks
	14 Ferries
C. Sites and Objects Pertaining to Early Indian Culture	1 Mounds
	2 Village sites
	3 Cache pits
	4 Petroglyphs
	5 Quarries
	6 Shell heaps
	7 Burial grounds

Fig. VI. 1

SYMBOLS SELECTED

Appropriate symbols were also selected to represent the following major resource categories and patterns representing the major human impacts of urbanization:



1. WATER AND ITS ENVIRONS
   - A. Water in Motion
   - B. Beaches
   - C. Wetlands
2. LAND FORMS
   - A. Rock Formations
   - B. Glacial Remains
   - C. Underground Caverns
   - D. Interesting Topography
3. VEGETATION
   - A. Trees & Shrubs
   - B. Wildflowers
   - C. Grasses
   - D. Aquatic Plants
4. WILDLIFE HABITAT
   - A. Animals
   - B. Upland Game Birds
   - C. Birds of Prey
   - D. Songbirds
   - E. Water Birds
5. CULTURAL RESOURCES.
   - A. Modern Structures
   - B. Historical Structures and Places
   - C. Sites and Objects Pertaining to Early Indian Culture
6. PARKS
   - A. Proposed Federal Park
   - B. Proposed State Park
   - C. Proposed County Park
   - D. Proposed Municipal Park
   - Existing Federal Park
   - Existing County Park
   - Existing State Park
   - Existing Municipal Park

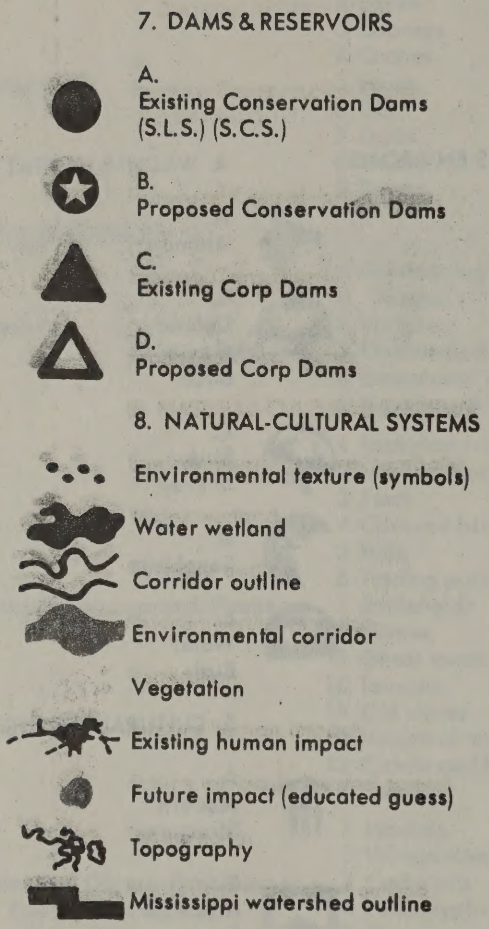

7. DAMS & RESERVOIRS
A.
Existing Conservation Dams
(S.L.S.) (S.C.S.)
B.
Proposed Conservation Dams
C.
Existing Corp Dams
D.
Proposed Corp Dams
8. NATURAL-CULTURAL SYSTEMS
Environmental texture (symbols)
Water wetland
Corridor outline
Environmental corridor
Vegetation
Existing human impact
Future impact (educated guess)
Topography
Mississippi watershed outline

Fig. VI.2

BASE MAPS FOR PLOTTING SELECTED

The inventories were prepared on 46 base maps available from the Army Map Service at a scale of 1:250,000.

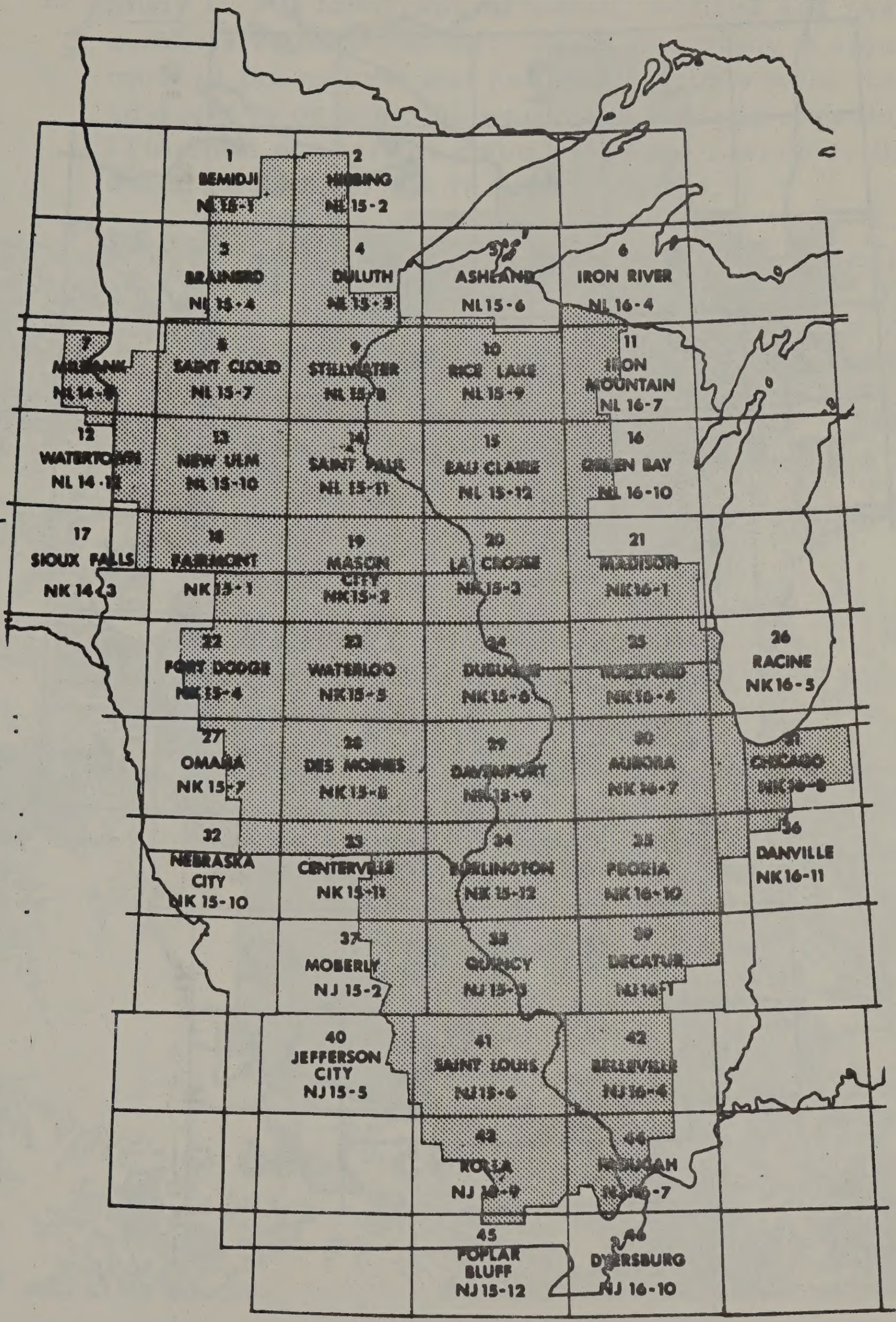


Fig. VI. 3

To simplify indexing and file work, each sheet was given a simple numerical number, as shown below.

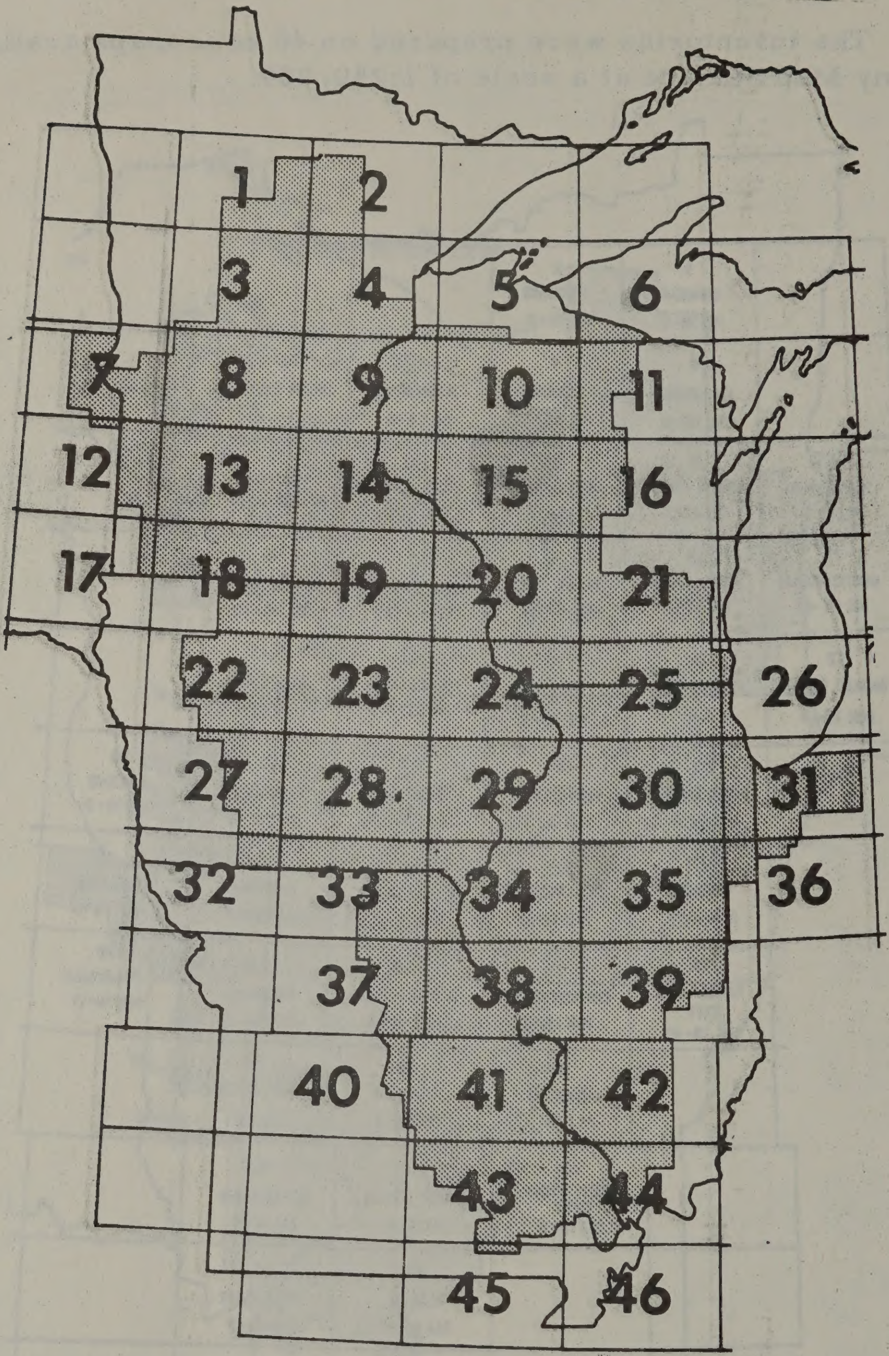


Fig. VI.4

How Maps Were Studied

Each map was studied in the following three ways:

1. Study 1: All topographic, water, wetland and resource symbols were identified. From this study it appeared that most of the natural and cultural symbols were located adjacent to or near the water and wetland corridor patterns. (Time did not permit identifying land corridors though this would be appropriate in future studies.)

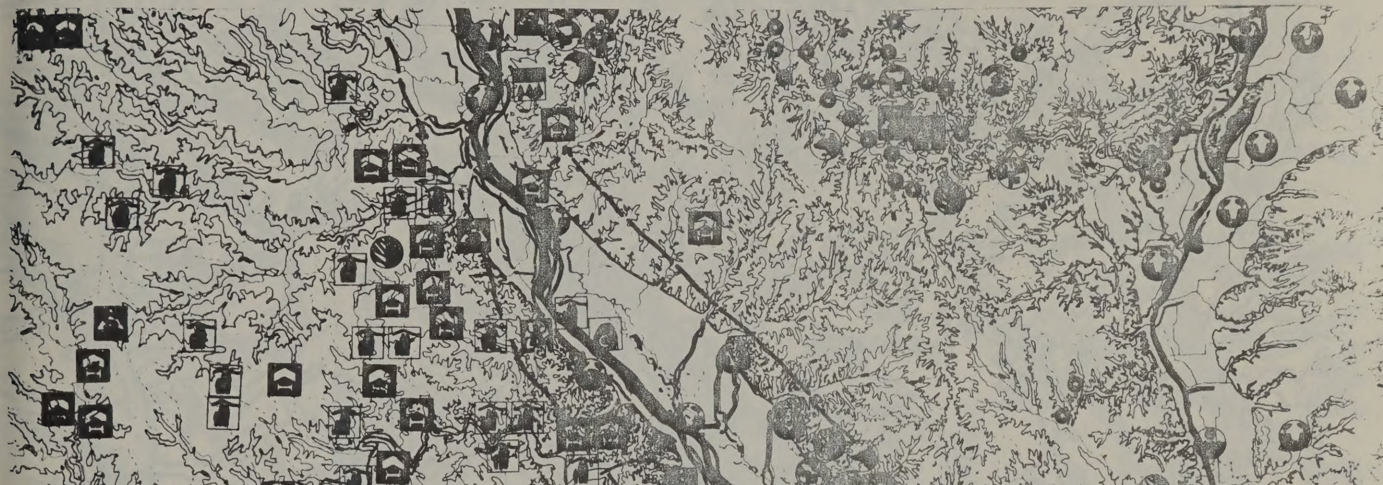


Fig. VI. 5

2. Study 2: All resource symbols were reduced to dots representing exact locations within the watershed. The concentrati of these dots represented areas of high environmental texture or diversity. After outlining the water-wetland corridors, it was demonstrated that most of the identified environmental texture was located within the corridor pattern.

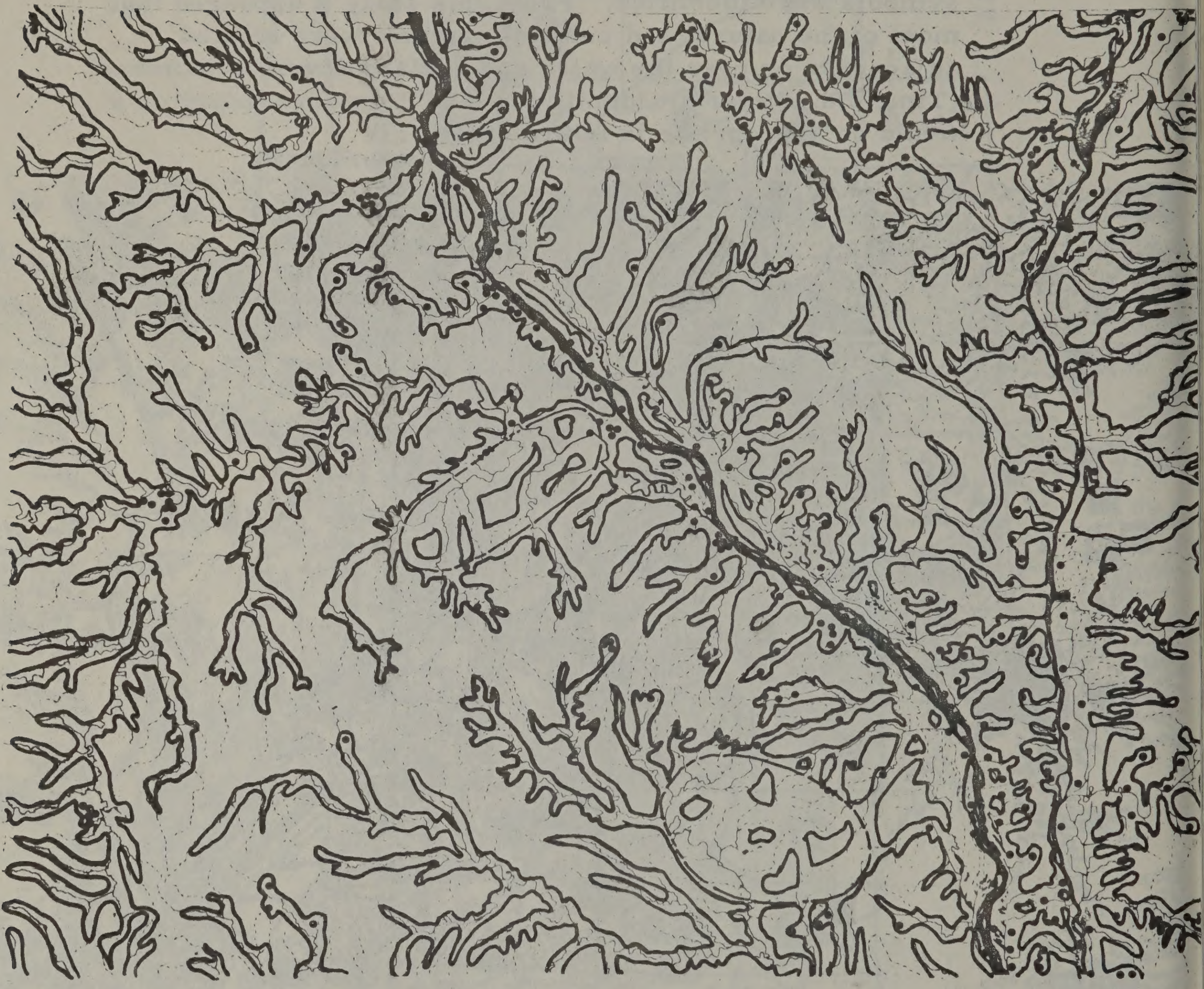


Fig. VI.6

3. Study 3: After plotting the solid water-wetland corridor and adding dots to represent areas of high environmental texture, the timber pattern was added. Also added were three human impact patterns as follows:

   a. All existing and projected urbanization

   b. All major existing highway systems

   c. All existing and proposed reservoirs (Army Corps and U.S. Soil Conservation Service reservoirs only)

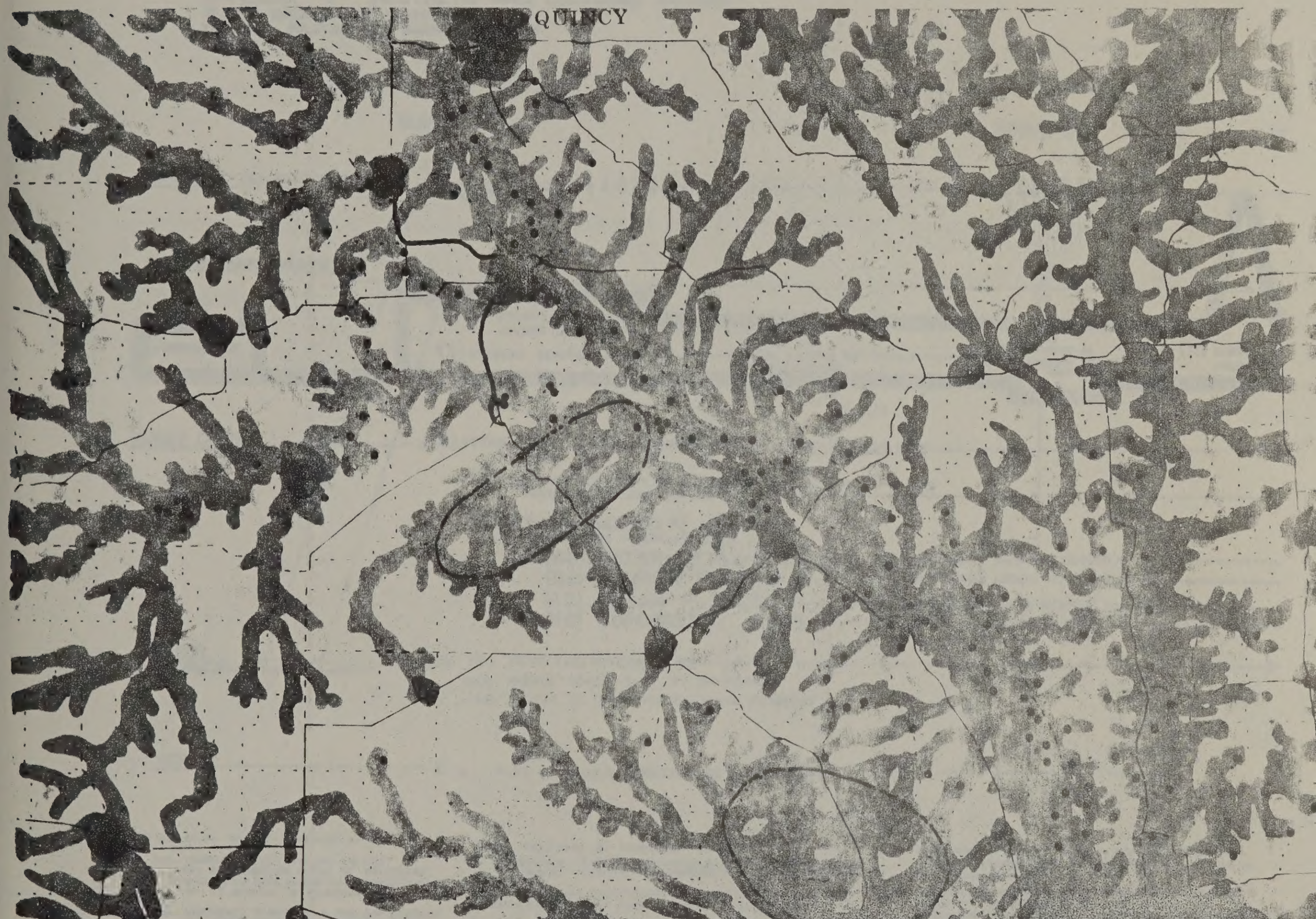


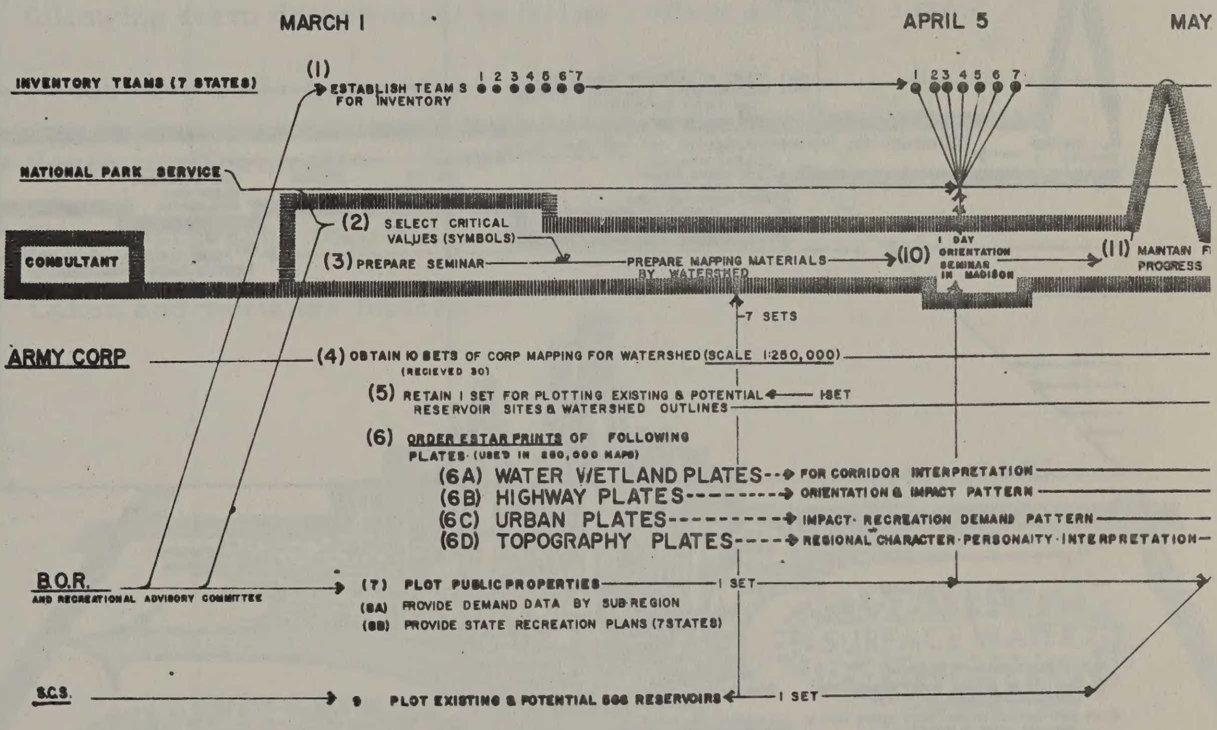
Fig. VI.7

All of these human impacts offer a potential threat to corridor resources. Their concentrated patterns suggest where detailed surveys should be encouraged as a basis for understanding the landscape carrying capacity and to serve as inputs for wise design guidelines.

SIX MONTH ORGANIZATIONAL CHART DRAFTED

The tasks involved in preparing the Upper Mississippi River Comprehensive Basin Study were shared by participating agencies and consulting personnel. The following chart identifies interagency responsibilities and time schedules during the six months allocated to preparing the report:

APPENDIX B. AESTHETIC AND CULTURAL VALUES
PHILIP H. LEWIS JR. AND ASSOCIATES
2900 1/2 COLUMBIA RD., MADISON, WISCONSIN


MARCH I
APRIL 5
MAY
INVENTORY TEAMS (7 STATES)
(1)
ESTABLISH TEAMS FOR INVENTORY
1 2 3 4 5 6 7
1 2 3 4 5 6 7
NATIONAL PARK SERVICE
CONSULTANT
(2) SELECT CRITICAL VALUES (SYMBOLS)
(3) PREPARE SEMINAR
PREPARE MAPPING MATERIALS BY WATERSHED
(10)
1 DAY ORIENTATION SEMINAR IN MADISON
(11) MAINTAIN F
PROGRESS
7 SETS
ARMY CORP
(4) OBTAIN 10 SETS OF CORP MAPPING FOR WATERSHED (SCALE 1:250,000)
(RECIEVED 30)
(5) RETAIN 1 SET FOR PLOTTING EXISTING & POTENTIAL RESERVOIR SITES & WATERSHED OUTLINES
1 SET
(6) ORDER ESTAR PRINTS OF FOLLOWING PLATES (USED IN 250,000 MAPS)
(6A) WATER WETLAND PLATES
FOR CORRIDOR INTERPRETATION
(6B) HIGHWAY PLATES
ORIENTATION & IMPACT PATTERN
(6C) URBAN PLATES
IMPACT · RECREATION DEMAND PATTERN
(6D) TOPOGRAPHY PLATES
REGIONAL CHARACTER · PERSONAITY · INTERPRETATION
B.O.R.
AND RECREATIONAL ADVISORY COMMITTEE
(7) PLOT PUBLIC PROPERTIES
1 SET
(8A) PROVIDE DEMAND DATA BY SUB-REGION
(8B) PROVIDE STATE RECREATION PLANS (7 STATES)
S.C.S.
9 PLOT EXISTING & POTENTIAL SCS RESERVOIRS
1 SET

● (1) STATE CONTACT IDENTIFIED BY N.P.S.

(2) SELECTION OF MOST CRITICAL VALUES FOR INVENTORY SELECTED BY CONSULTANT, ● N.P.S. CORPS & B.O.R. EITHER BY CORRESPONDENCE OR BY MEETING IN MADISON.

(3) CONSULTANT TO PREPARE A ONE DAY SEMINAR FOR FIELD CONTACTS, (INVENTORY TEAMS)

● (4) ARMY CORP OBTAINS 10 SETS OF 1:250,000 MAPPING-COVERING WATERSHED AND SEND 7 SETS TO CONSULTANT, 1 SET TO S.C.S. 1 SET TO B.O.R. & RETAINS ONE SET.

● (5) CORP MAPS, ON MYLAR OVERLAYS AT 1:250,000 A. EXISTING RESERVOIR SITES, B. POTENTIAL RESERVOIR SITES, C. WATERSHED BOUNDARIES.

● (6) CORP OBTAINS ESTAR PRINTS OF PLATES THAT PRINTED 1:250,000 MAPPING 6A, 6B, 6C, 6D. ASSIGNMENT [illegible] SHOULD BE IN CONSULTANTS HANDS BY JUNE 1, 1967. WATER, WETLAND, & TOPO PLATES SHOULD HAVE HIGHEST PRIORITIES.

● (7) B.O.R. MAPS ON OVERLAY AT 1:250,000
A) PUBLIC PROPERTIES (EXISTING & PROPOSED) CONSULTANT SHOULD RECIEVE THIS INFORMATION BY JUNE 1, 1967

● (8A) RECREATION DEMAND DATA TO BE PROVIDED BY MAY 1, 67 &

● (8B) STATE RECREATION PLANS PROVIDED TO CONSULTANT BY B.O.R. BY THE SAME DATE.

● (9) PLOT ON OVERLAY— ARMY MAPPING SET 1:250,000.

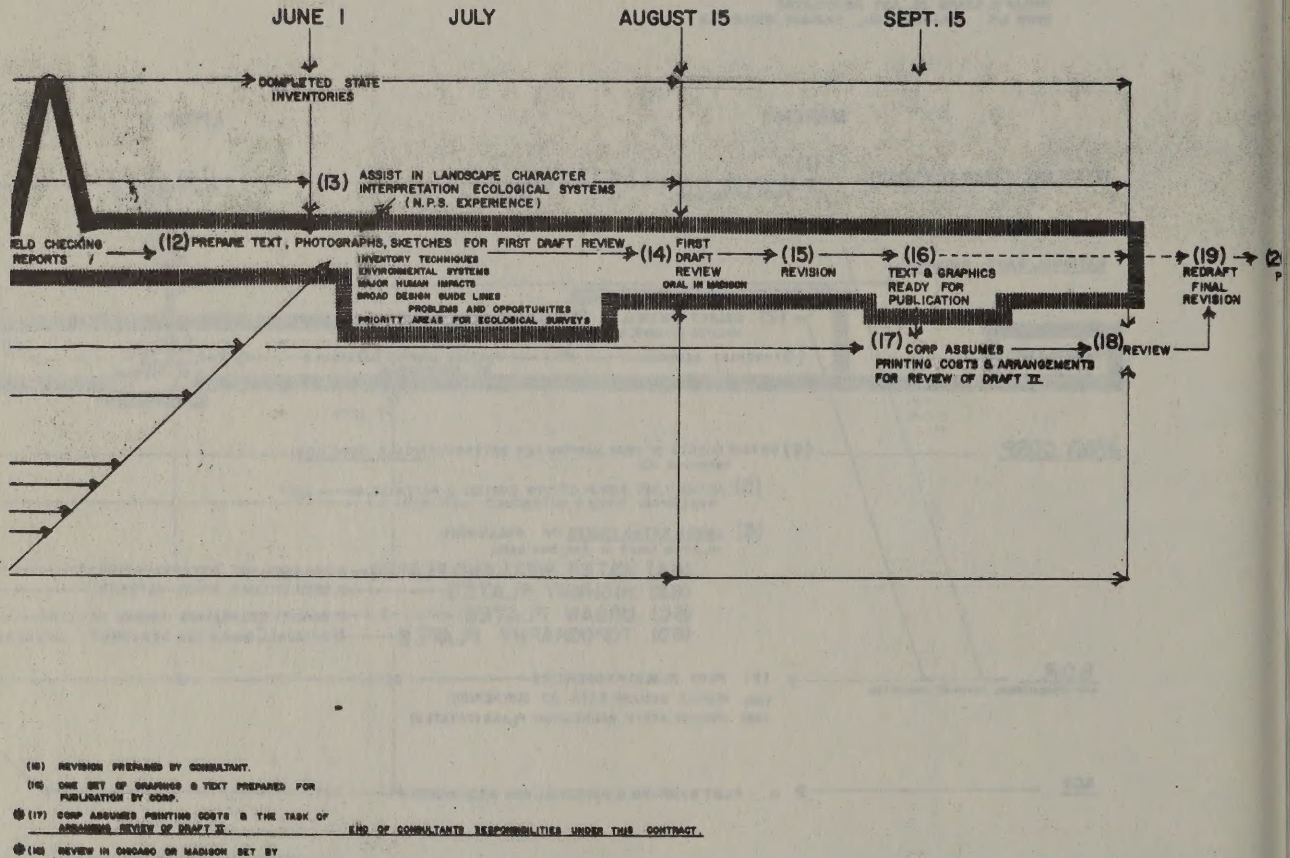
(10) SEMINAR TO BE CONDUCTED BY CONSULTANT APRIL 5TH, BASE MAPS AND INSTRUCTIONS TO STATE INVENTORY TEAMS GIVEN. FINAL MATERIALS PREPARED UNDER FIRST N.P.S. CONTRACT TO BE UTILIZED IN THIS PRESENTATION. NO TRAVEL OR PER DIEM EXPENSES FOR FIELD PERSONNAL PROVIDED UNDER THIS CONTRACT. (FOR RECREATION ADVISORY COMMITTEE.)

(11) CLOSE CONTRACTS WILL BE MAINTAINED WITH FIELD PERSONNEL. A FEDERAL LINE IN THE COORDINATORS (INTERIOR) OFFICE WOULD BE MOST USEFULL FOR THIS TASK.

(12) INTEGRATION OF ALL BASIC RESOURCE INVENTORIES BEGINS. THE GOAL FOR RECEIVING ALL BASIC DATA WOULD BE JUNE 1 AND NO LATER THAN JULY 1.

(13) ASSISTANCE FROM N.P.S. IN IDENTIFYING ECOLOGICAL SYSTEMS IS IMPORTANT. THE CONSULTANT WILL HAVE CERTAIN BASIC INFORMATION BUT WILL WANT TO CROSS CHECK WITH N.P.S. DATA & EXPERIENCE IN THE TASK. N.P.S. SHOULD ALSO PROVIDE THE CONSULTANT WITH ANY PART PLANS PREPARED WITHIN THE WATERSHED I.E. GREAT RIVER ROAD, APOSTLE ISLAND PLANS, EFFIGY MOUND NATIONAL PARK ETC.

(14) SECOND SEMINAR PREPARED FOR ORAL REVIEW OF FIRST DRAFT IN MADISON. AGAIN NO TRAVEL OR PER DIEM FOR REVIEWING PERSONNEL PROVIDED UNDER THIS CONTRACT. (FOR RECREATION ADVISORY COMMITTEE.)


JUNE 1
JULY
AUGUST 15
SEPT. 15
COMPLETED STATE INVENTORIES
(13) ASSIST IN LANDSCAPE CHARACTER INTERPRETATION ECOLOGICAL SYSTEMS (N.P.S. EXPERIENCE)
ELD CHECKING REPORTS
(12) PREPARE TEXT, PHOTOGRAPHS, SKETCHES FOR FIRST DRAFT REVIEW
INVENTORY TECHNIQUES
ENVIRONMENTAL SYSTEMS
MAJOR HUMAN IMPACTS
BROAD DESIGN GUIDE LINES
PROBLEMS AND OPPORTUNITIES
PRIORITY AREAS FOR ECOLOGICAL SURVEYS
(14) FIRST DRAFT REVIEW
ORAL IN MADISON
(15) REVISION
(16) TEXT & GRAPHICS READY FOR PUBLICATION
(17) CORP ASSUMES PRINTING COSTS & ARRANGEMENTS FOR REVIEW OF DRAFT II
(18) REVIEW
(19) REDRAFT FINAL REVISION
(2
P

(15) REVISION PREPARED BY CONSULTANT.

(16) ONE SET OF GRAPHICS & TEXT PREPARED FOR PUBLICATION BY CORP.

● (17) CORP ASSUMES PRINTING COSTS & THE TASK OF ARRANGING REVIEW OF DRAFT II. END OF CONSULTANTS RESPONSIBILITIES UNDER THIS CONTRACT.

● (18) REVIEW IN CHICAGO OR MADISON SET BY RECREATION ADVISORY COMMITTEE AND CORP.

(19) REDRAFT OF DRAFT II BY THE CONSULTANT SHOULD BE NEGOTIATED UNDER NEW CONTRACT.

● ALL REQUESTS FOR FEDERAL-STATE AGENCY ASSISTANCE SHALL BE MADE BY N.R.S. (WITH HELP OF COORDINATOR AS NECESSARY) - THROUGH RECREATION ADVISORY COMMITTEE.

Fig. VI.9

Chapter VII

DESIGN CHARACTERISTICS OF FORM DETERMINANTS

It is one thing to recognize and protect form determinant patterns that are important to human survival, well-being and happiness, and quite another to design various land uses in their fringe areas without encroachment. Both tasks are important to environmental quality planning. When considering the design of these human facilities in the fringe areas, the concern must be with adjusting man-made forms in harmony with basic natural and cultural forms.

AREAL AND CORRIDOR FORMS

The following form determinant patterns reflect an areal form:

1. Productive soils (natural)
2. Vegetation (natural)
3. Steep topography (natural)
4. Lakes and wetlands (natural)

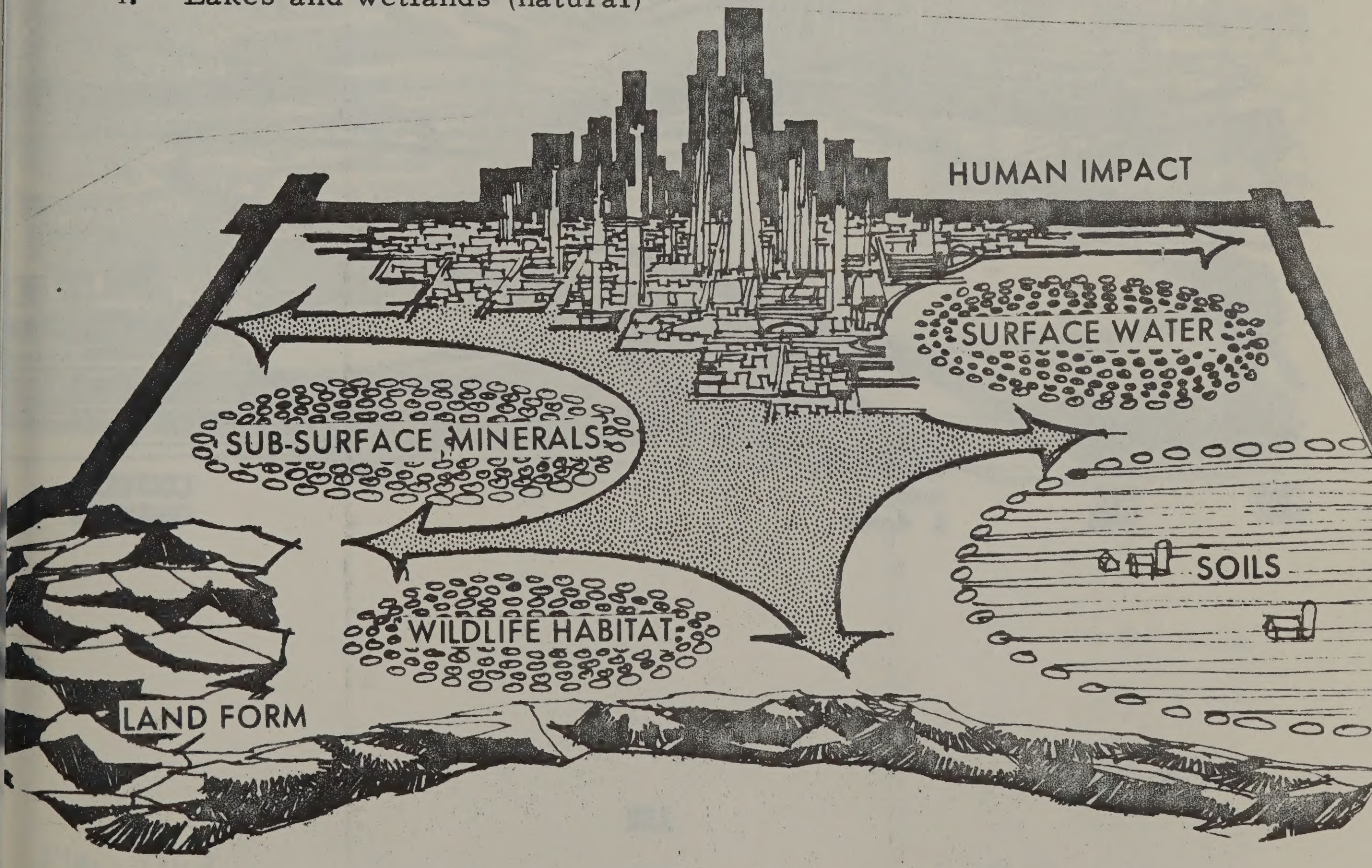


Fig. VII. 1

In contrast to areal forms are narrow, linear, ribbon-like forms such as:

1. Highways (cultural)

2. Utilities (cultural)

3. Railways (cultural)

4. Rivers (natural)

5. Streams (natural)

6. Rim and slope patterns (natural)

These forms (the last three of which are environmental corridors) link and integrate the areal forms.

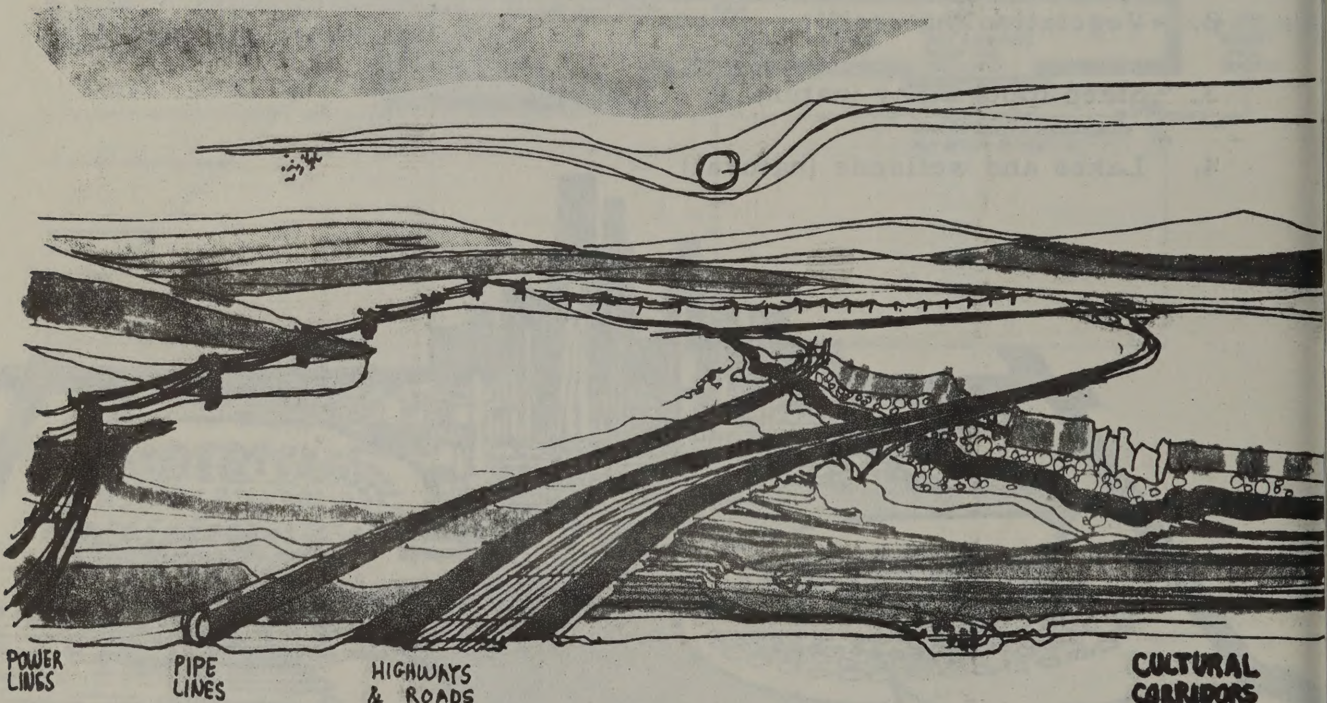


Fig. VII. 2

Natural Corridors and Cultural Corridors

The "natural" integrators may be called natural corridors, while the man-made integrators may be called cultural corridors.

Both the natural and cultural corridors may be called environmental corridors or movement systems for it is along and through these environmental patterns or within their fringe areas that people, power and merchandise are often moved. The design of cultural corridors can direct and restrict human impact to strategic areas in ways that will not destroy natural areal and corridor quality.

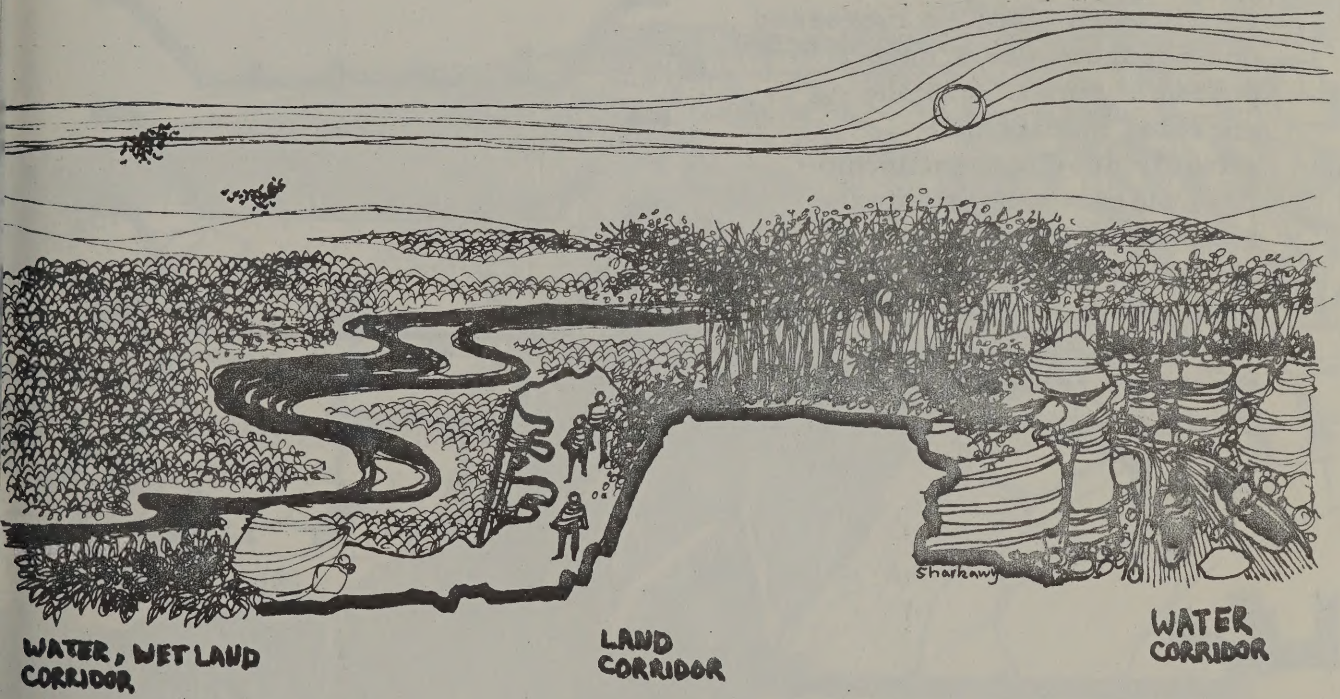


Fig. VII. 3

DESIGNING FACILITIES AND LAND USES ADJACENT TO AREAL AND CORRIDOR PATTERNS

Environmental planning and design is not only the art of protecting and enhancing areal and corridor patterns, but the art of manipulating new man-made (cultural) patterns in their fringe areas without destroying them.

Corridor Fringe Areas

By protecting the corridors and encouraging new patterns of development within the fringe areas, the tax base of the counties could be increased and assured over a longer period of time. It is the corridor quality that attracts development in the first place. Loss to single rows of cabins and other unplanned physical development offers an alternative of quality obliteration or expensive rehabilitation by future generations.

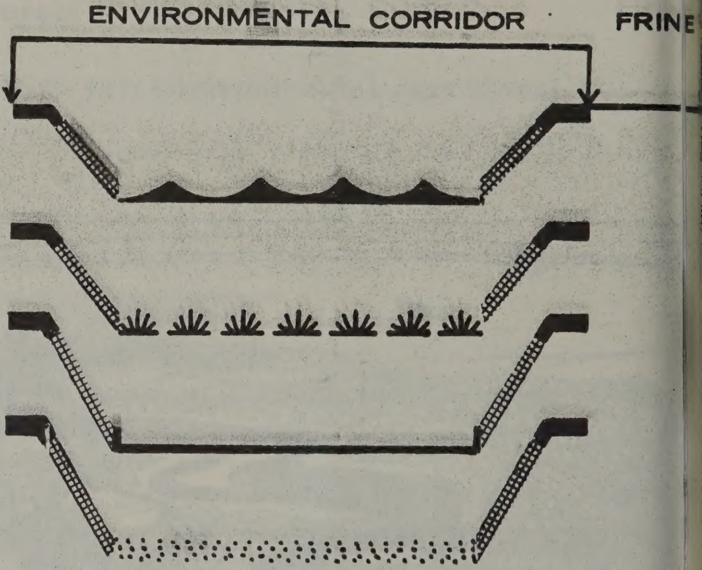


Fig. VII. 4

Natural Areal Pattern (Water) Development

Too often, water pollution, soil erosion and elimination of natural scenic beauty are the result of the traditional types of lake shoreline development. Preservation of shoreline timber and visual amenities and efficient sewage disposal can be achieved by well-designed cluster cottage development and a consolidation of dock and beach facilities as shown in the illustrations below.

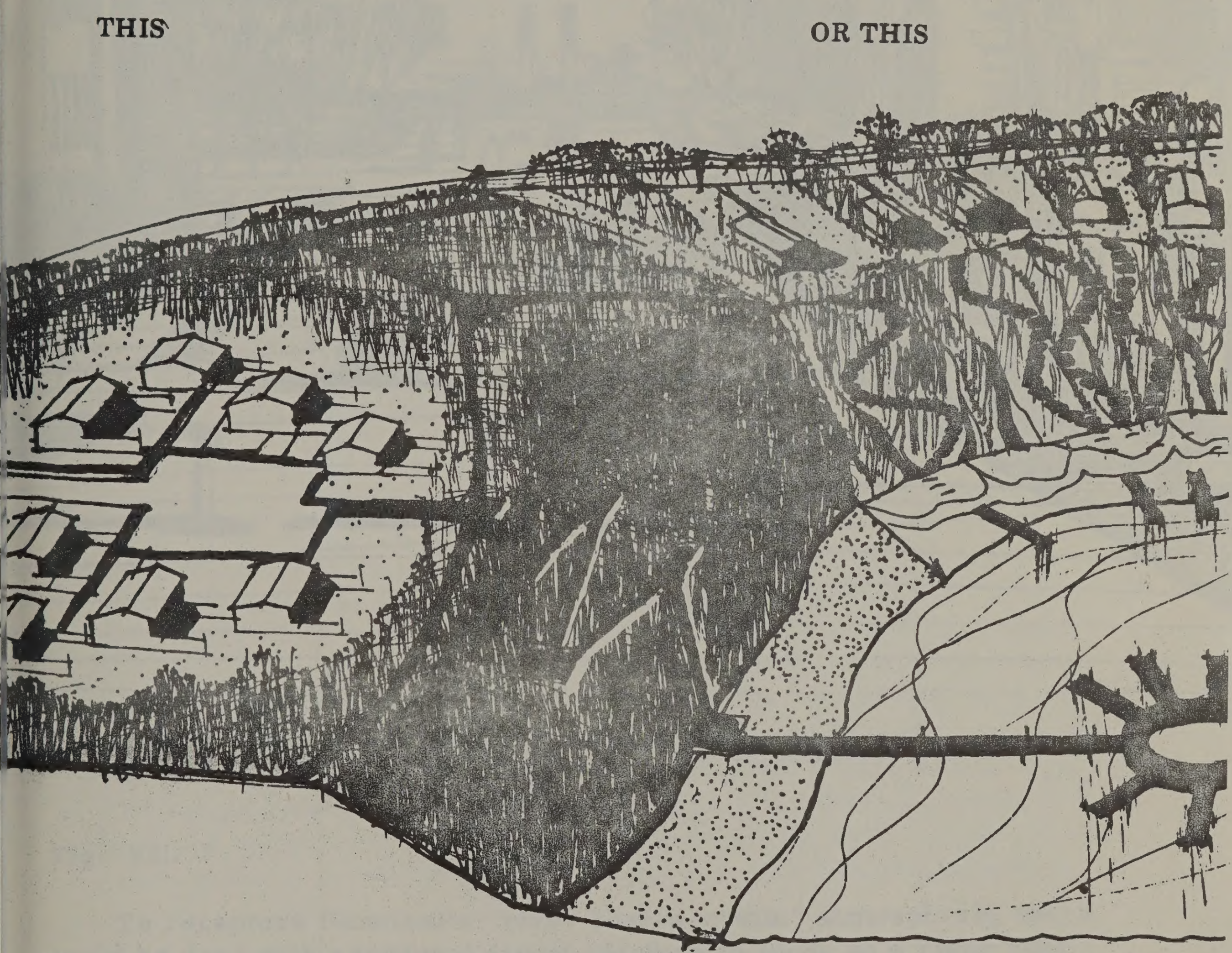


Fig. VII. 5

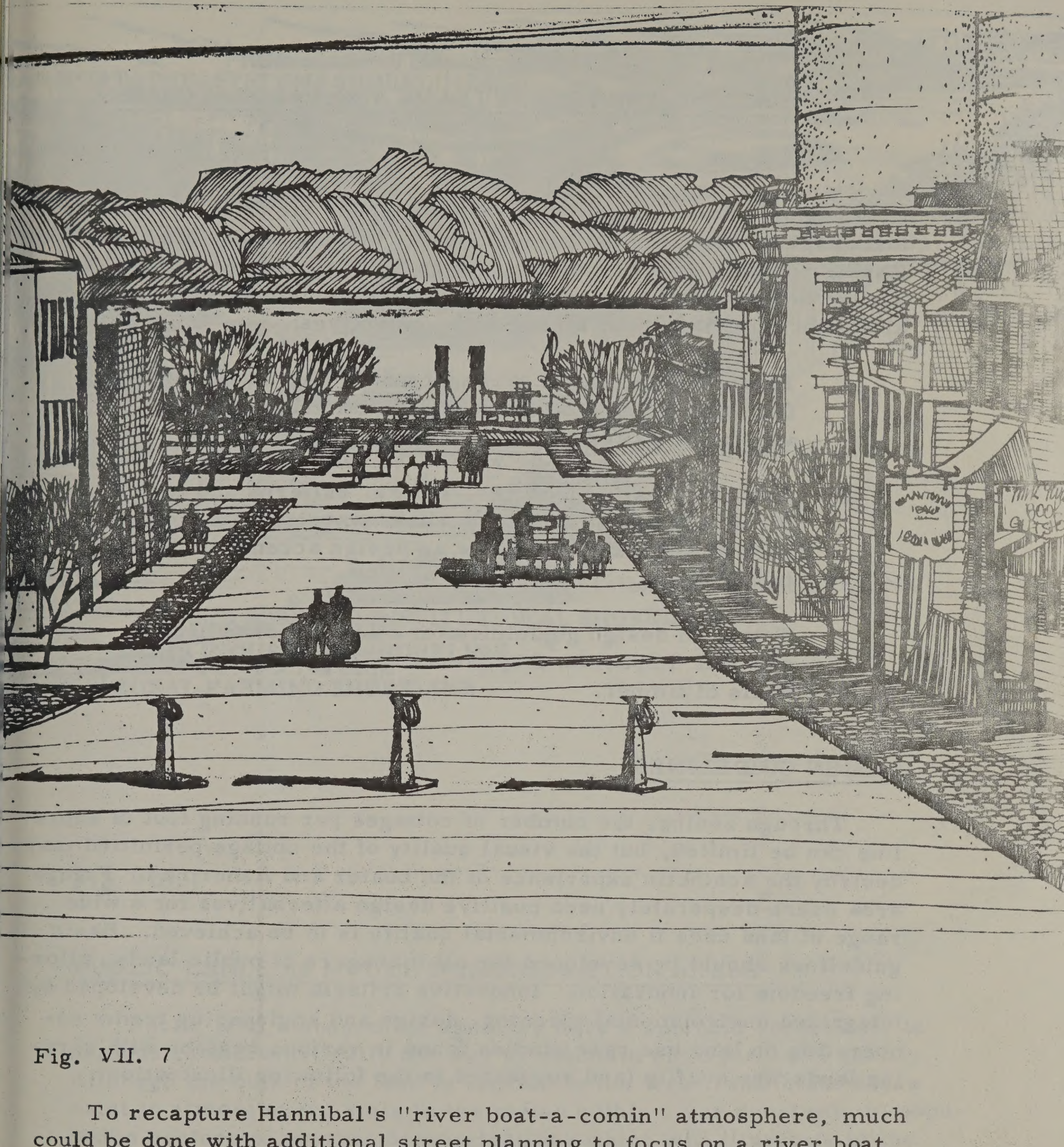


Fig. VII. 7

To recapture Hannibal's "river boat-a-comin" atmosphere, much could be done with additional street planning to focus on a river boat scene. Such a boat could serve as a museum, restaurant and rest stop for the visitor to Hannibal, Missouri.

Chapter VIII

PLANNING AND DESIGN TEAMS AND LABORATORIES

Design criteria for guiding development in the fringe areas of areal and corridor resource patterns are sadly lacking on private lands. Zoning controls or public agency policy for land use, although badly needed in most instances, do not necessarily establish three dimensional design criteria which, among many objectives:

1. Establish the spatial arrangement of houses and other facilities in harmony with the spatial characteristics of vegetation patterns and land form;
2. Offer alternative textures, colors, patterns and forms for structures so that they will harmonize with their natural surrounds or serve as design accents in the landscape;
3. Establish design guidelines for trail, roadway, 'cut' and 'fill' impact as they pierce rolling hillsides and walls of timber.

DESIGN GUIDELINES

Through zoning, the number of cottages per running foot of shoreline can be limited, but the visual quality of the cottage permitted may destroy the aesthetic experience of the boater and fisherman. Fringe area users desperately need positive design alternatives for a wide range of land uses if environmental quality is to be achieved. Basic guidelines should be developed for all managers of public lands, allowing freedom for innovation. Innovative criteria might be developed by integrated environmental planning, design and engineering teams cooperating on land use case studies found in various regions with varying landscape quality (and suggested in the following illustration).

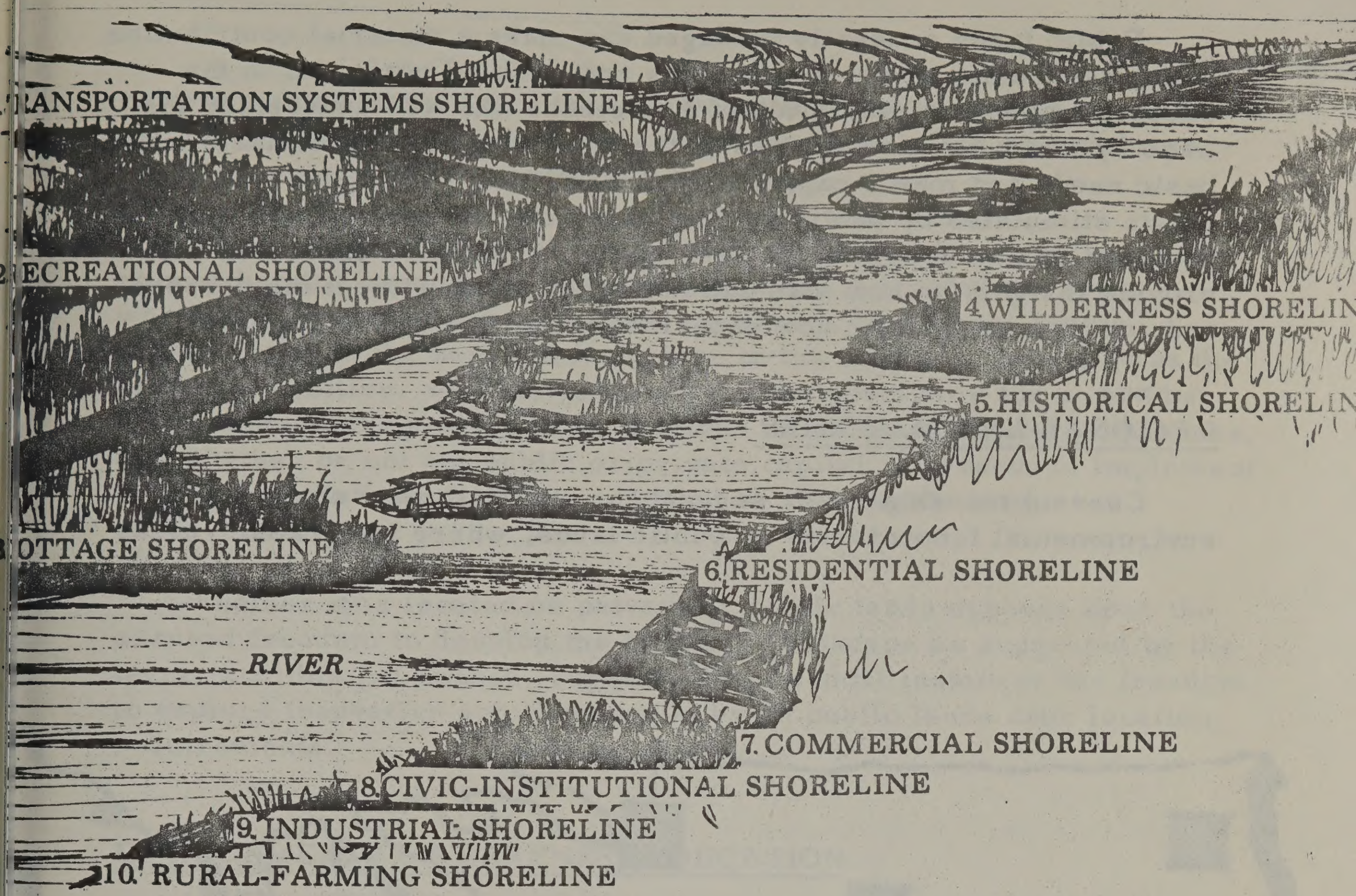


Fig. VIII. 1

PUBLIC LANDS AS MODEL DEMONSTRATION AREAS

Public land management agencies have a splendid opportunity to demonstrate dramatically the way to maintain environmental quality. Although the bulk of the land is located in the West, sufficient acres exist in almost every state in the nation within close proximity to population centers to provide demonstrations which will illustrate to the public, cities, towns and villages and private developers the manner by which human use of landscapes can be in harmony with intrinsic values. The need is obvious now and will become greater as the nation continues to grow, as pressures for economic exploitation increase and as populations rise.

Public lands prudently managed can make a material contribution to the reordering of personal values and national goals and to the education of a new generation of Americans who will understand the ways by which harmonious use of the environment is essential to man's basic needs and man's capability for a full life. Thus, an awakened public stimulated by public land management demonstrations showing how land can be used without destroying its intrinsic character will provide insights on how man can use other lands without the personal and societal anguish we now experience with this nation's growth.

REGIONAL LABORATORIES

Current trends already suggest the establishment of regional environmental laboratories on public lands, where integrated

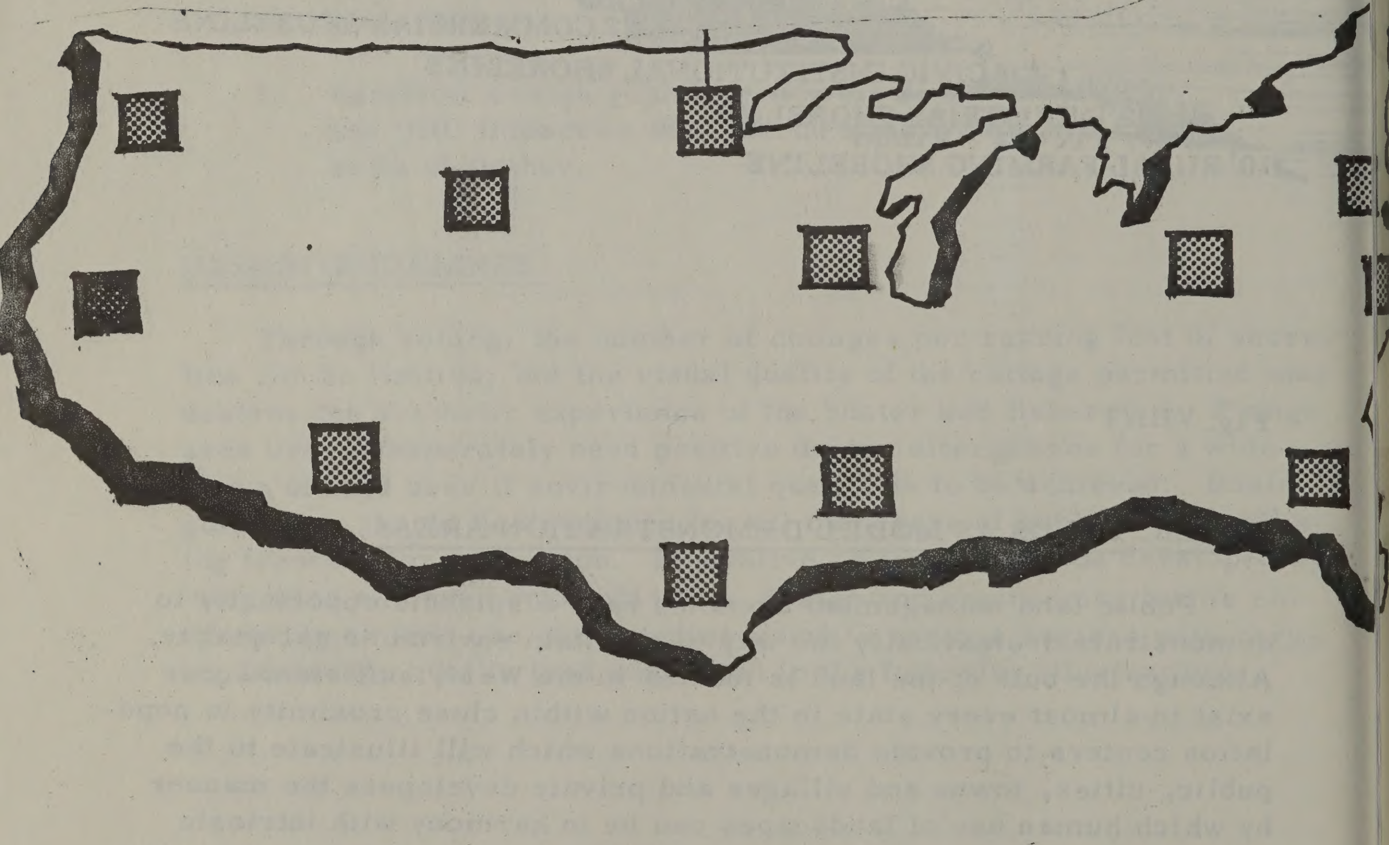


Fig. VIII. 2

environmental teams from local universities, government agencies, and private industry could focus their breadth of talent on understanding local problems and opportunities.

The location of such laboratories should depend in large measure on whether the breadth of professional talent is located nearby, whether it is close to the legislative bodies of the nearby states, whether it is in the back yard or close to the bright young minds at the state universities, whether there exists an opportunity for a number of governmental agencies to be involved in the planning-design process, and whether or not the public or private capital is present to implement innovative solutions that are identified by this highly integrated endeavor.

Whether it is located on private or public lands depends upon the assured freedom to develop the land and landscape as suggested by the team, and this, of course, suggests that in most instances the freedom to explore innovative solutions would be on public lands near location requirements.

ENVIRONMENTAL AWARENESS EDUCATION

Success of any present or future governmental program to identify environmental quality, within laboratories on public lands does not, of course, assure its protection and wise development. Techniques must be developed for presenting these environmental studies as mentioned in the preceding chapters to all levels of the responsible agency structure and to the general public in conceptual and pictorial form.

Until clear pictures and concepts about man and his environment, the problems, potentials and casual relationships are disseminated and become part of the common stock of environmental planning knowledge, there can be little progress in guiding human impact in harmony with identified natural and cultural value patterns of the particular region.

Recent advances in audio-visual presentation have developed a more direct relationship between the subject and educational materials. Nothing short of exploring these new dioramas, three-dimensional movies, computer-programmed slides and think tanks will do if we are to develop environmental awareness.

It is generally conceded that if environmental quality is to be restored in America, public re-education to the life-giving imperatives and the intrinsic natural values is essential. It is also essential that if public land management agencies are to address themselves to the full meaning of environmental quality, then they must undergo a reorientation. All agency personnel should be encouraged to participate in agency and inter-agency classes, seminars and demonstration projects. Planning generalists should be trained to obtain an overview of all resource opportunities, to coordinate the work of the individual functional specialists. The subject of environmental quality should be taken seriously by all agency employees, and considered as a long-term need rather than just a popular passing expedient.

NEEDED: A NATIONAL ENVIRONMENTAL PLAN

If the national battle to overcome environmental degradation can be compared to the task of winning World War II, the teaching and communication techniques utilized in that conflict could be used to reorient and re-train millions of young people in a relatively short time. Within weeks and months the butcher, baker, lawyer and chief were retrained to handle highly complicated tasks with the development of training films, link trainers and field laboratories.

A comprehensive national environmental interpretation plan for strategically located awareness centers located on public lands near major urban concentrations would be a worthy goal.

The term "interpretive" is used broadly to encompass services to visitors of public lands, environmental education for staff and public alike, public information and public relations. By "plan" we mean a continuing effort that begins at once and carries forward on and off strategic sites.

Mission of Awareness Centers

The primary mission of such awareness centers would be to support and enhance the purposes and concepts as laid out in the master plans for the individual public land parcel. As an example these might include plans

1. To develop a recreation facility in consonance with the protection of fragile natural and cultural features;

2. To maximize cooperative arrangements with neighboring institutions and instrumentalities;

3. To promote year-round use;

4. To stimulate environmental awareness, education, research, and service activities;

5. To energize regional planning;

6. To employ indigenous designs and themes.

INDIANA DUNES PILOT PROJECT

Such a plan was detailed for the National Park Service by Landscapes, Inc. for the Indiana Dunes National Lakeshore.

At Indiana Dunes was found in stark relief the basic conflict in Park Service posture: to what extent can you preserve "vignettes of primitive America" while at the same time catering to "the benefit and enjoyment of the people?" The Landscapes, Inc. prospectus stated that interpretation can help to resolve the conflict by helping visitors and staff understand the different possibilities for the Lakeshore.

The Lakeshore as a Part of Its Surroundings

The real need is for visitors to see the Lakeshore as a part of a total system in which they and their own urban communities are included, to see that the forces that shape and control natural communities are precisely those forces that man has unleashed and accelerated in shaping his own communities. This new attitude toward environment can come about in two ways: first, by making crystal-clear to visitors the past natural values that once existed on the Lakeshore and then the results of their impact on natural areas within the Lakeshore; and second, by integrating Park Service planning concepts with planning commissions and other organizations charged with environmental house keeping in the Gary-Calumet region.

In short, helping shape public attitudes toward natural and urban problems and even assisting in their solution can lead people to understand what is special about the park itself, a park that is part of the urban fabric and yet apart from it.

Obviously, such an overall strategy cannot be implemented overnight. It involves a process, an approach that is suggested throughout this report must permeate management as well as interpretation in a particular direction over time.

An Environmental Awareness-Regional Planning Center at the Dunes

The main thrust of the prospectus recommended an environmental awareness and regional planning center, a complex of planning and interpretive facilities--made so exciting that it would constitute the prime recreational experience of the Lakeshore, dramatizing the unique ecological and economic glory of the area and preserving rare nooks and crannies from over-visitation.

Such a working and interpretive center could lend focus to indigenous regional planning efforts and dramatize the consulting and catalyst role of the Park Service, HUD and the Corps. of Engineers, all working on separate but related problems in this area.

Without a leadership role on the part of federal agencies, the whole Lakeshore may really prove to be unmanageable if not ungovernable.

The center itself should be so sited on the outer fringe of the Lakeshore that it can become a mass-use center and yet avoid degradation of the park levels.

What Visitors Would See at the Dunes Center

In the center the visitor would be able to step back into time to see visually the heritage of the dunes, would be able to monitor on live closed-circuit television the realities of the present, and would be able to step into the future to see what entente could be designed between man and land. The net objective would be to relate the visitor to his changing regional environment and to suggest, through demonstrations, the ways he can effect change for good or ill.

One recommendation in the Landscapes, Inc. report suggests a terratarium as part of the environmental awareness center. The visualizers have created a planetarium to look at the stars, why not a device where people could look down at the earth resources. In the proposed Dunes Terratorium, visitors would walk into a rotunda above the earth's surface. Moving images would be projected from underneath at different scales of distance. These could range from astronaut level orbiting the moon, then zoom into North America, the Great Lakes

Insert for PURC Environment rept. Part II - Vol. IV

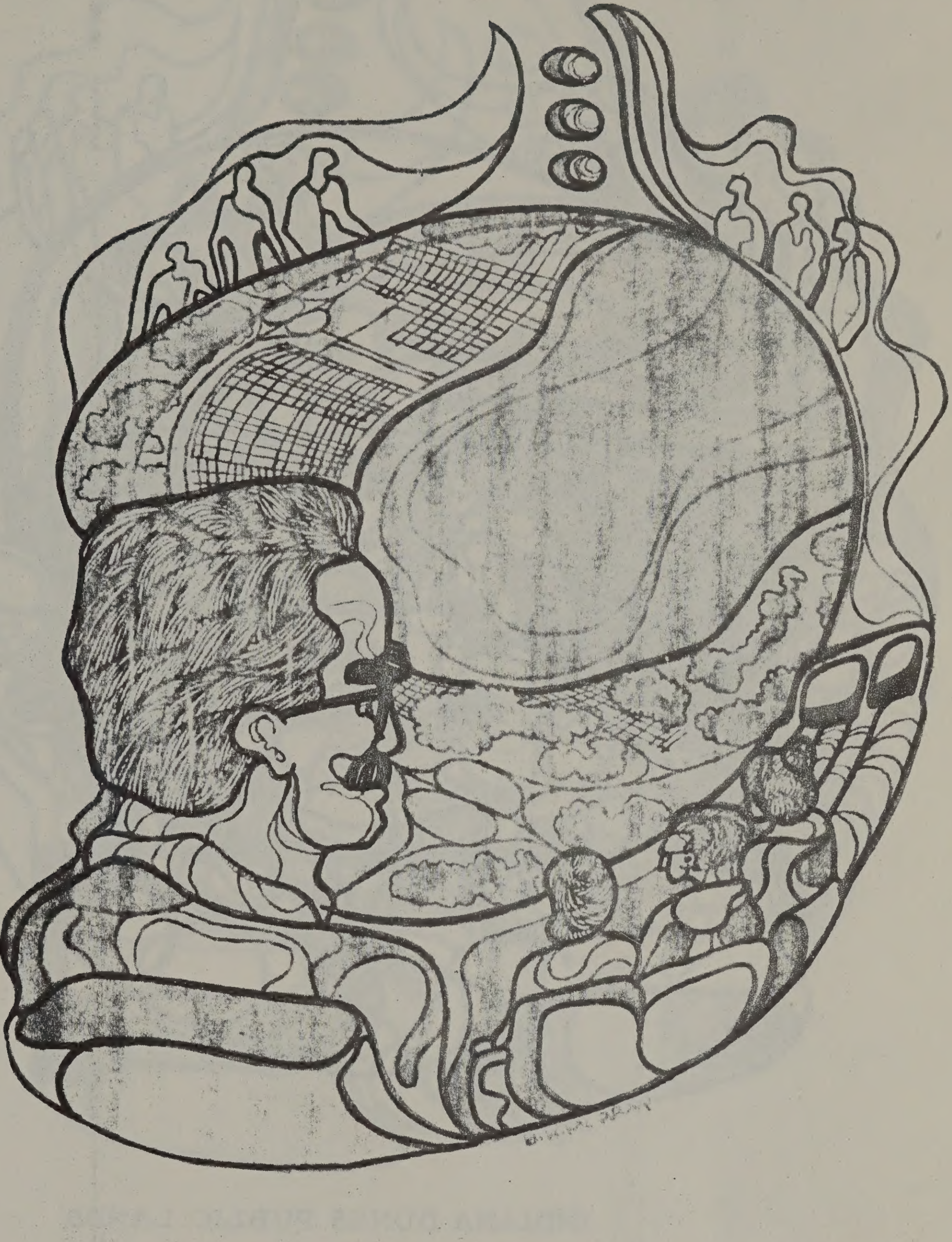
region, the Calumet region, the Indiana Dunes public lands, to the Pinhook Bog, to a pitcher plant or a blueberry in the bog.

ASTRONAUT LEVEL

Fig. VIII. 3

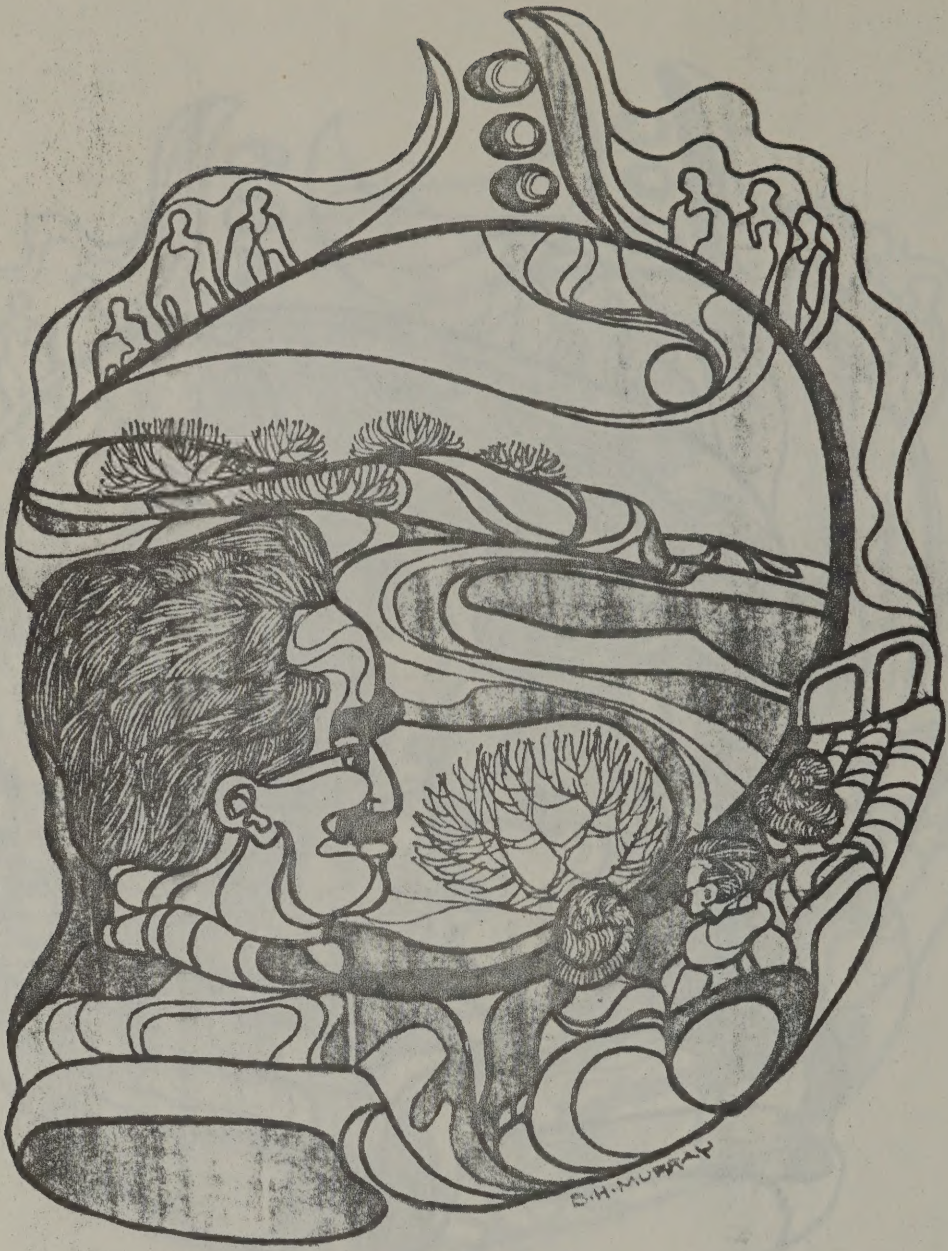
NORTH AMERICAN GREAT LAKES REGION

Fig. VIII. 4



CALUMET REGION

Fig. VIII. 5



INDIANA DUNES PUBLIC LANDS

Fig. VIII. 6

PINHOOK BOG AND PITCHER PLANT

Fig. VIII. 7

NEEDED: A SYSTEM OF ENVIRONMENTAL AWARENESS CENTERS

The pilot model environmental center at Indiana Dunes and one being planned in Madison, Wisconsin, could be followed by a national system of centers--each tailored to the region in which it is located. In such centers, the soil scientist could identify the many soils that will provide good crops as well as those that can be expected to withstand heavy recreational traffic. The wildlife expert could identify quality wetlands for wildlife habitat. The architectural historian could identify man-made structures with historical quality. The forester could identify quality patterns of timber, the anthropologist quality patterns of prehistoric culture. The botanist and ecologist could identify unique ecological communities with values for present and future generations, and the landscape architect could identify landscape patterns with unique perceptual qualities--and so on until we have exhausted the number of professions studying the physical qualities of the landscape.

To each of these many experienced professionals, there are compelling reasons to preserve the values known to them for the present and future beauty and utility of the particular regional laboratory.

The years of research within each profession to develop a better understanding and use of their particular resource should not go unheeded. An effort to understand each other's responsibilities should be encouraged in our age of narrowing specialities. It has been the past and present taxpayer's willingness to provide the classrooms, the research laboratories and the extensional activities, that has provided us with the opportunity to evaluate quality within these many classified resources.

By focusing the diverse talent of the region, representing all levels of government, education and private industry on a limited geographic area, collaborative effort between agencies, between professions, and between private and public interests could be encouraged.

Goals of Environmental Awareness Centers

The primary goal of such centers would be much more than merely rediscovering the many landscape resources in terms of parks, play, recreation and fun. It would be concerned with identifying, preserving and developing wisely, regional landscape patterns that provide a source of strength, spiritual health and wisdom for the individual, patterns that contain a heritage of experiences and inner development beyond price.

The center concept is based on the assumption that mankind can accept the idea that the world's resources are limited and that the reproductive capacity of man must be restricted before natural forces of famine and disease determine his maximum population and that he will accept the idea that although science can discover and interpret laws of nature, it cannot repeal them.

It would then follow that man as a permanent resident of the world could organize the use of space and resources and proceed to plan his regions and communities in which life would be a rewarding experience.

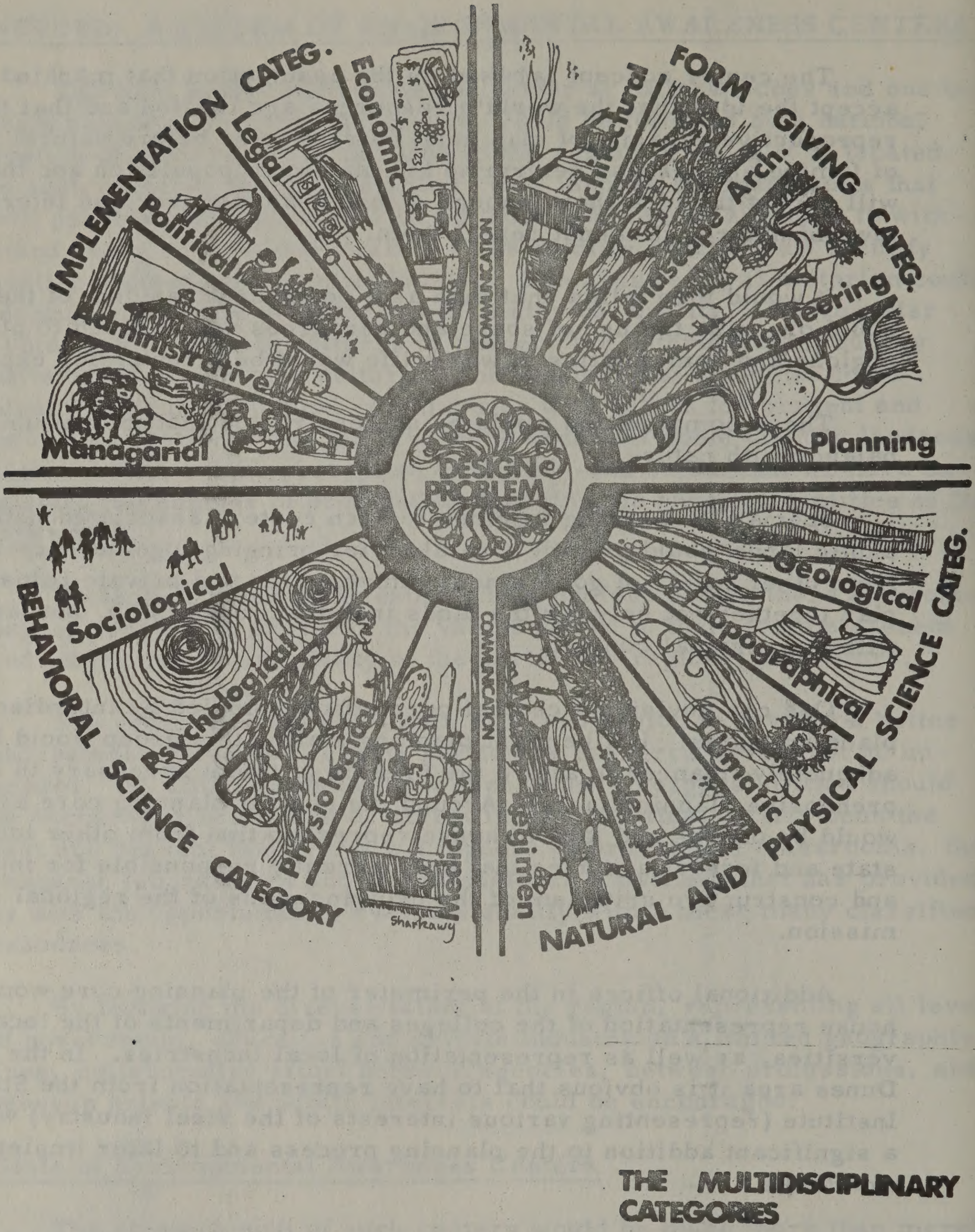
These communities would be so constructed that they would be in balance with nature.

Specialists working together in such centers associated with the public lands would provide a catalyst for bringing together expertise from other levels of government, universities and private industry to plan together not only for the lands in federal ownership, but lands within a regional context.

One can envision a central core office occupied by interdisciplinary planning teams. Unlike most planning staffs, this group would be adequately financed to afford the breadth of talent necessary in comprehensive planning tasks. Around the central planning core activities would be offices and labs to house representation from other local, state and federal agencies that are currently responsible for inputs and constructive criticism of the evolving plans of the regional commission.

Additional offices in the perimeter of the planning core would house representation of the colleges and departments of the local universities, as well as representation of local industries. In the Indiana Dunes area it is obvious that to have representation from the Steel Institute (representing various interests of the steel industry) would be a significant addition to the planning process and to later implementation tasks.

The utilization and maintenance of environment whatever the use may be requires a broad scope of responsible leadership. This growing popular concern for the future of America's resources is reaching a scale resulting in a proliferation of involvement and attendant lack of coordination, thereby resulting in organization problems of significant dimension.



THE MULTIDISCIPLINARY CATEGORIES

Vig. VIII. 8

THE AWARENESS CENTER CONCEPT

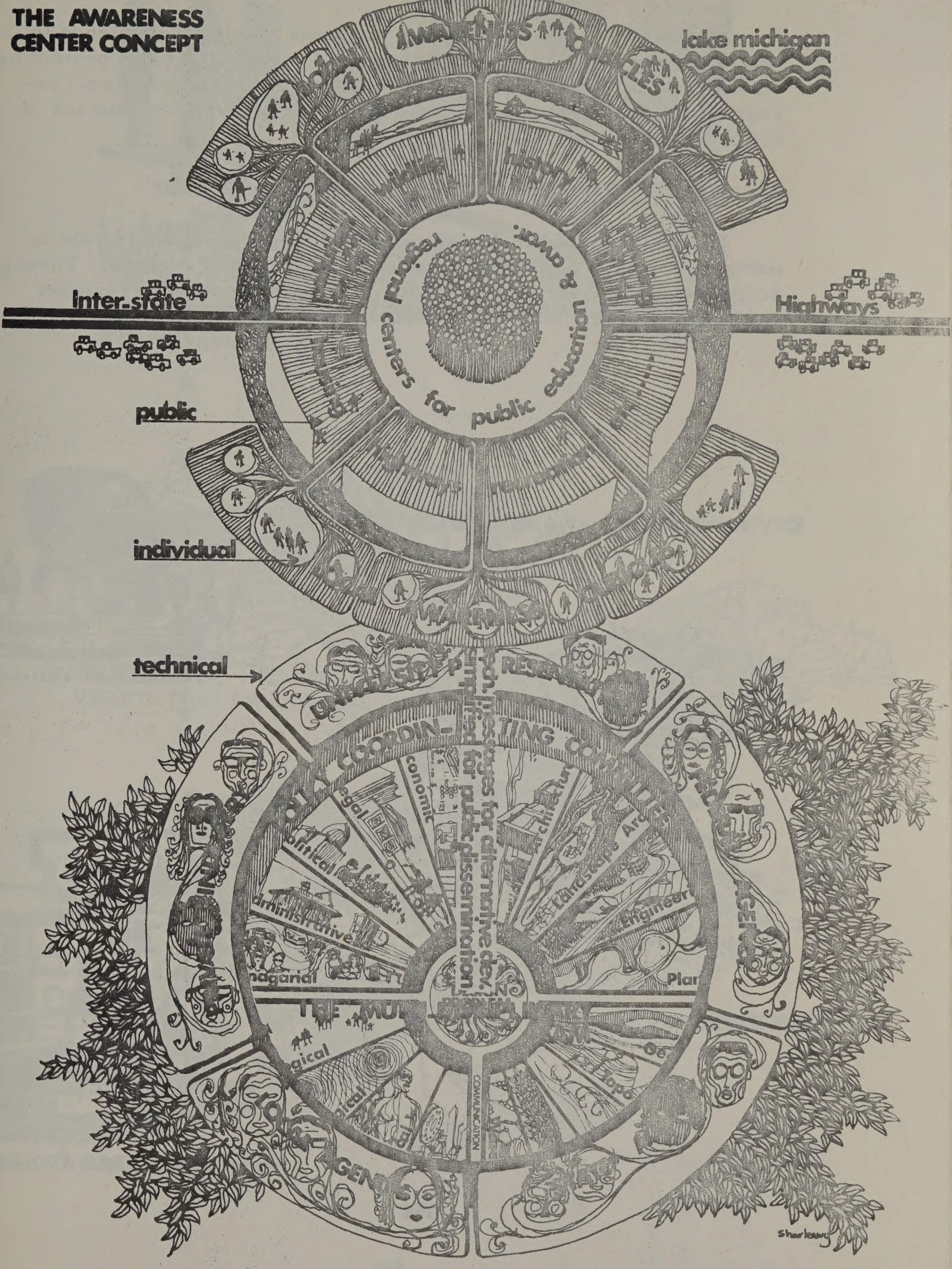


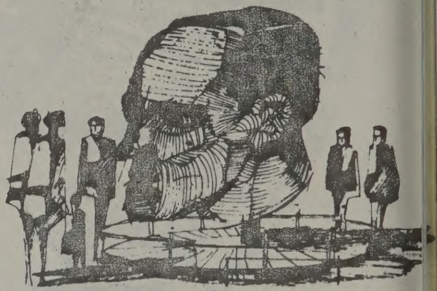
Fig. VIII. 9

An awareness of this problem suggests a critical challenge to regional awareness centers in the task of coordinating and promoting a consolidated program of action by the intellectual and fiscal resources operating within the region once the alternative courses of action are identified.

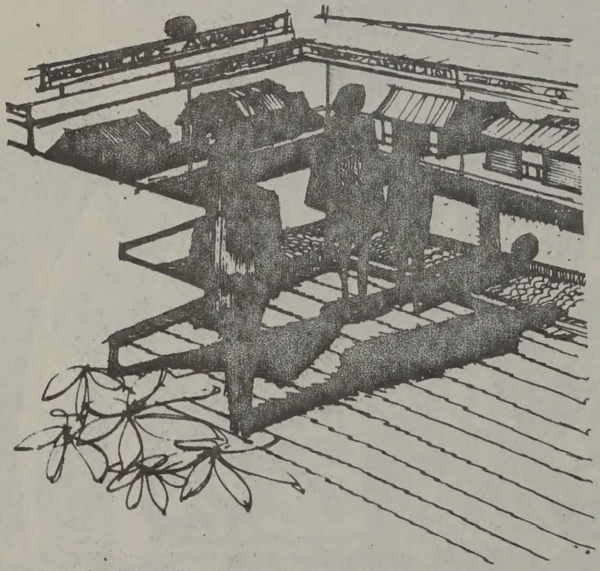
Anatomy of an Environmental Awareness Center

The richness of the human environmental experience would be portrayed in the regional environmental awareness centers. Through dramatic and innovative visual aids, the ingredients of a regional environment would be communicated to members of the public.

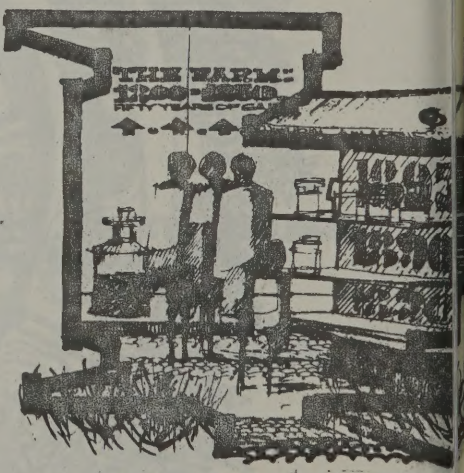
ENVIRONMENTAL AWARENESS CENTER



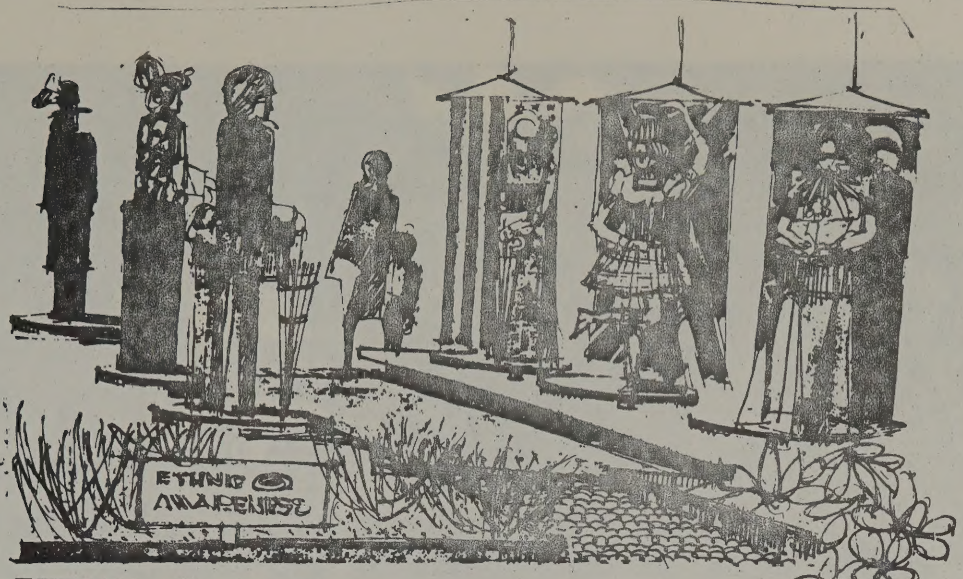
HUMAN PHYSIOLOGY



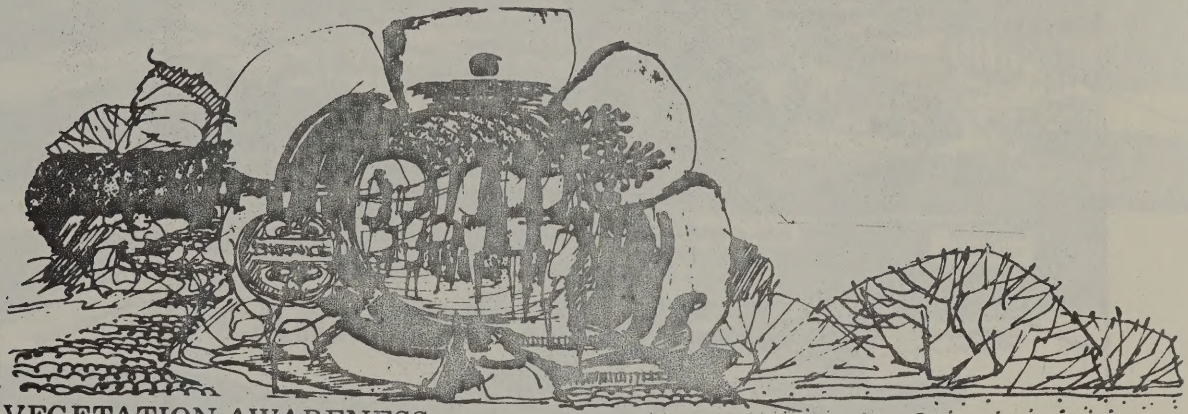
ARCHITECTURE AWARENESS



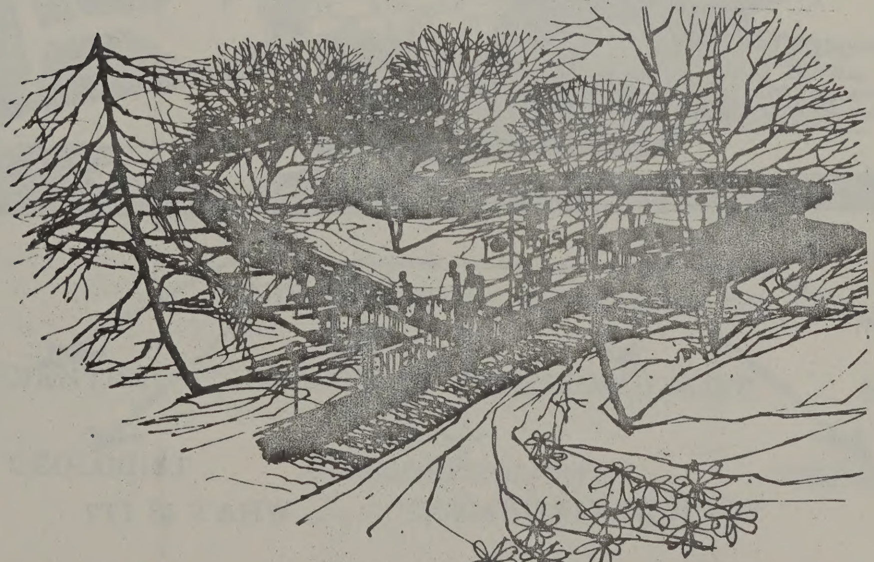
CULTURAL AWARENES



ETHNIC AWARENESS

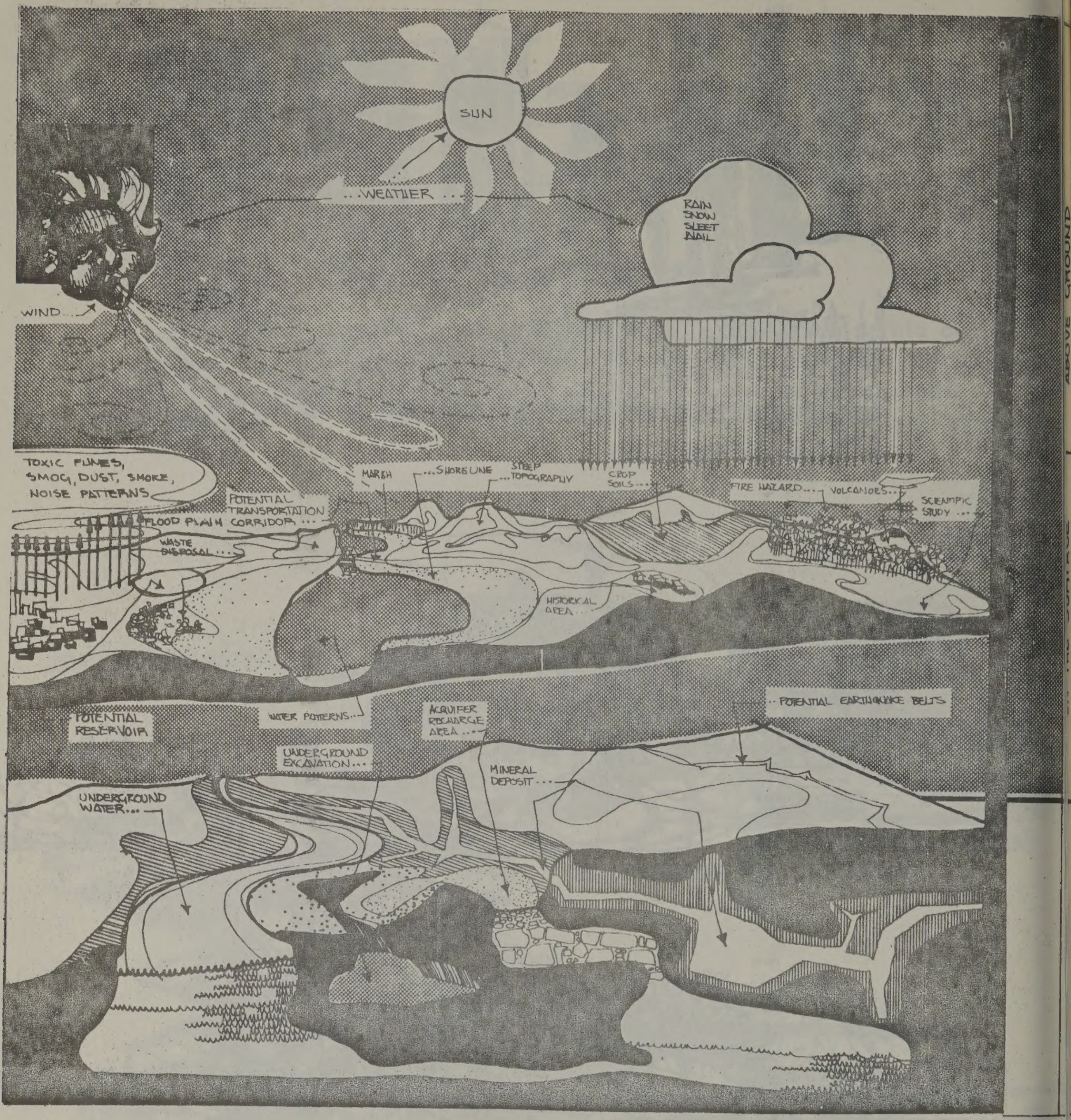


VEGETATION AWARENESS



SOILS AWARENESS

Fig. VIII. 10



YOUR ENVIRONMENT . . . WHAT IS IT?

Fig. VIII. 11

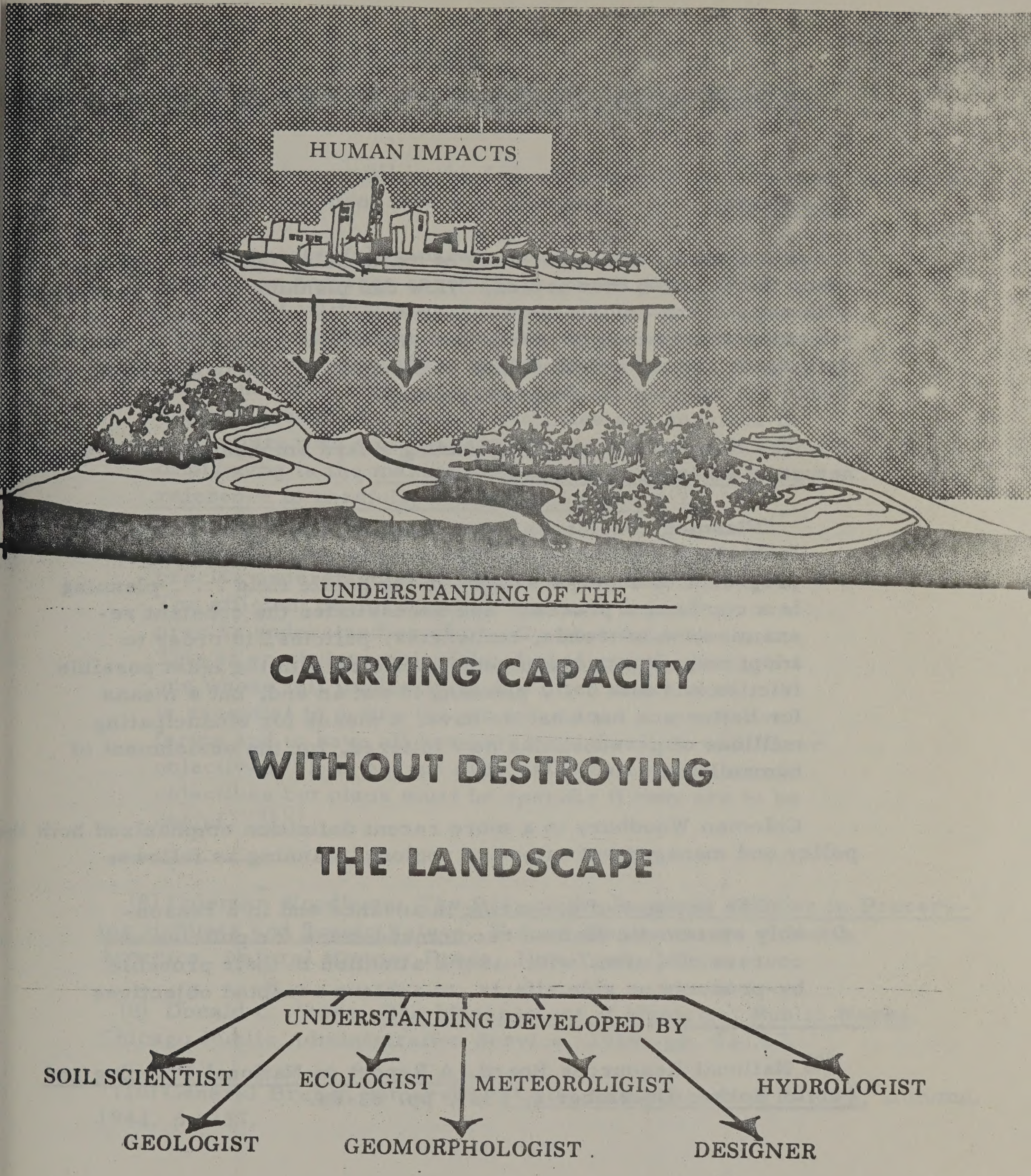

HUMAN IMPACTS
UNDERSTANDING OF THE
CARRYING CAPACITY
WITHOUT DESTROYING
THE LANDSCAPE
UNDERSTANDING DEVELOPED BY
SOIL SCIENTIST
ECOLOGIST
METEOROLIGIST
HYDROLOGIST
GEOLOGIST
GEOMORPHOLOGIST
DESIGNER

Fig. VIII. 12

Chapter IX

ENVIRONMENTAL PLANNING AND THE FEDERAL INSTITUTION

PLANNING

Recognizing the importance of maintaining optimum conditions for man, the question then arises, "How can planning be done specifically with respect for environmental quality on the public lands?" The following discussion addresses the question of planning, its various definitions and the relationships of planning for environmental quality within the responsible federal agencies.

The National Resources Planning Board emphasized the policy nature of planning as follows:

> "Planning consists in the systematic continuous, forward-looking application of the best intelligence available to programs of common affairs in the public field . . . planning is a continuous process, and necessitates the constant re-examination of trends, tendencies, policies, in order to adopt and adjust governmental policies with the least possible friction and loss . . . planning is not an end, but a means for better use for what we have, a means for emancipating millions of personalities now fettered, for the enrichment of human life . . . ." (7)

Coleman Woodbury in a more recent definition emphasized both the policy and management nature of regional planning as follows:

> "The process of preparing in advance and in a reasonably systematic fashion recommendations for policies and courses of action, with careful attention to their probable by-products or side effects, to achieve accepted objectives

---

(7) National Resources Board, A Report on National Planning and Public Works, December 1, 1934, pp. 83-84.

> in the common life of urban or regional localities or communities." (8)

Stone and Somervill in the following definitions stressed the administrative, management nature of planning:

> "The successful management and control of any large enterprise requires carefully prepared plans which seek to forecast its future operations as accurately as possible . . . . Effective management necessitates definite and comprehensive plans for all its activities. Both long term and short term plans are needed . . . for the orderly growth of all public facilities and services in conformity with social and economic values. The kernel of planning is the making of day to day decisions with reference to carefully constructed plans." (9)

> "The first factor [of successful management] is a precise understanding of the job to be done . . . . The efficient performance of any task depends upon a precise understanding of exactly what the task is. This is an obvious principle of good management, but one whose full implications are often overlooked. It is essential to define the job to be done in quantative terms and to have all key personnel familiar with those objectives. It is not too difficult to determine broad objectives but plans must be specific if they are to be useful." (10)

---

(8) Coleman Woodbury, The Role of the Regional Planner in Preserving Habitats and Scenic Values, Future Environments of North America, Natural History Press, New York, 1966.

(9) Donald C. Stone, The Management of Municipal Public Works, Chicago Public Administration Service, 1939, pp. 63, 67.

(10) General Brehon Somervill, Public Administration Review, Autumn, 1944, p. 257.

The first two definitions are concerned with public policy in its broadest sense. This type of planning is obviously a first prerequisite for environmental quality planning on public lands. The work of the Public Land Law Review Commission is in fact addressed to "national policies planning." As the work of the Commission goes forward and becomes the subject of discussion and debate in the Congress, the members of Congress become the public policy planners as well as those who are in policy formulation positions in the executive branch. The results could be a public policy declaration by the Congress which will articulate new parameters for specific planning by public land management agencies.

Policies Plans versus Physical Comprehensive Land Use Plans

Although the first two definitions emphasize policies, they likewise stress the continuous nature of planning, and as public land management agencies refocus their programs in line with new environmental policies, they should likewise assume a positive attitude regarding their future role in clarifying the need for amending, modifying and strengthening these national policies. In this discussion it is important to note the distinction which must be made between "policies plans" and specific physical comprehensive land use plans for public lands with which this report is concerned. Before the latter can proceed, the policy decision must be made.

Planning Goals and Procedures

Once national policy has been decided, the public agency has a twofold task. First, the agency must make clear to the personnel in the agency, to constituent clientele groups and to the general public what these basic policy decisions or value judgments are, and if possible, their basis and their probable impacts on agency management programs. Moreover, the agency must commit itself fully to these policy decisions. Second, the agency must initiate appropriate administrative action to implement specific comprehensive resource planning within the agency.

The planning task which the agency faces includes three major phases:

1. An interpretation of agency objectives based on an analysis of national policy declaration;

2. A measurement of the existing agency program in the light of these new objectives; and

3. A design or plan for a program of positive action.

A broad declaration of public policy regarding the preservation and enhancement of environmental quality on public lands will in turn have to be quantified and spelled out in substantial detail by each agency to be meaningful for agency programs. Hopefully, the policy declaration will itself be spelled out in sufficient detail to guide specific agency goal or objectives formulation.

Major irreversible decisions (such as those regarding construction of dams or oil shale extraction) which materially change the character of the landscape might best be left for subsequent Congressional decision. The large scale value judgments which must be made may be more appropriately resolved in the national interest through a political process than through agency administrative decision.

Definition of Agency Objectives

Assuming appropriate guidelines, the agency must still define goals with respect to its internal management responsibilities. For example, lands which support rare and endangered wildlife species (the California condor; the black-footed ferret, etc.) are to be reserved exclusively for perpetuation of those species; plant associations which have high scientific research purposes will be preserved; outstanding gorges, waterfalls, mountain tops will be protected; campgrounds will not be permitted immediately adjacent water courses to protect the view of the landscape especially from the water, etc.

Each level in the agency should participate in formulating such goals. Otherwise they may not be realistic or, though realistic, may not be understood or subscribed to by key administrative units in the agency. Also, the process is not a one-time task; it must be a continuous ongoing effort which will over time make a meaningful contribution to the evolution of new policy declarations.

Measuring Existing Programs

The second step, that of measuring the existing situation, is discussed in detail in other sections of this report which describe current land use impacts, those which must be anticipated in the future, and the techniques for actual measurement of environmental quality on public lands.

Programs of Positive Action

The action plan is the third phase. For public lands, it will express a means of preservation and enhancement of environmental quality on a map or series of maps; the quality will be delineated and ranked in terms of importance and related to current and projected uses. Also, the plan will include a discussion of relevant laws, policies, goals, rules and regulations germane to the plan.

Because of potential serious conflicts between traditional land uses and environmental quality considerations, some initial plans might consist of a series of alternatives to be reviewed by higher levels in the agency for policy guidance and decision making. In some instances conflicts may be so sharp that referral back to the Congress for national value judgments may be appropriate. Where conflict is not significant and environmental considerations can become an ongoing part of an agency's programs, there may only be one initial plan.

CHARACTERISTICS WHICH DISTINGUISH PUBLIC LAND PLANNING

Planning for lands in public ownership differs in several important ways from other types of government planning. First, planners can be in close juxtaposition with decision makers, or in fact can be both planners and decision makers.

Second, because the land is publicly owned, planning recommendations can be directly implemented. This contrasts with the advisory nature of much American planning which relies mainly on persuasion and a pluralistic approach to decision making. Furthermore, the federal government has a financial capability to implement plans which is substantially greater than other organizations.

Third, although public land planning should influence decisions made in the private sector which may infringe on public lands, its primary purpose is to guide agency land management decisions.

Fourth, the broad array of land use controls necessary to implement many government plans do not have to be brought into play on public lands. For example, it is not necessary to implement a public land plan with a local zoning ordinance.

Fifth, local public support for plans and public involvement in the planning process does not have to be a determining element, although in a broad sense, general public support will be essential for a viable agency program. However, the dominance of intimately involved constituent groups in typical non-public land planning (such as urban planning and zoning) need not be a major characteristic of planning for the public lands. For these federal public lands the plans can be evolved within broader paramenters reflecting sweeping national goals in contrast to the warp often given local plans by influencial clientel groups. (It should be noted, however, that public land agencies frequently do not exploit this considerable advantage and have been over-responsive to local interests, especially to those represented by commodity production.)

Sixth, the planner may have more insulation from short term political considerations. Thus, his plans can represent a longer range national purpose, articulated of course in the final analysis, through the political process. This, for example, is a marked contrast to a chief planner who advises a city mayor who runs for re-election each two years. Moreover, the size alone of the federal executive branch insures an insulation of the public land management agency planner several steps removed from policy positions where short run political considerations are weighed.

Seventh, planning and budgeting can occur side by side and simultanious decisions can be made to implement plans, in contrast to planning where functions are separated institutionally and where decisions are made in different time sequences.

Planning Advantages Enjoyed by Public Land Agencies

These characteristics provided some significant advantages to implementation of plans on public lands. These need to be fully exploited to achieve environmental quality goals. They give the agencies a unique position to plan for management programs which will serve as models of human use in harmony with the environment.

With the innate advantage that public land agencies have, it is imperative that if environmental quality is to be maintained on public land, the process of inventory, interpretation, analysis and synthesis must be linked closely with the agencies decision-making and implementation processes. Finely-tuned communication between participants who make a wide range of resource management decisions is essential to achieve a common understanding of specific environmental goals. Because resource decisions must be made in a long range political context, broadly public involvement in the process of both planning and decision making is also essential. Without a viable interplay, planning proposals may not reflect national goals agreed to through a political process and likely may not have captured the support necessary to influence decisions affecting implementation.

AGENCY STRUCTURE AND PLANNING INFLUENCES

The following discussion generalizes on the structure of government land management agencies, mentions several pertinent influences upon the planning processes and identifies other salient features of government actions.

The concepts discussed in general terms herein are not specifically indentifiable with a single agency, but are collectively representative of the following group of agencies: Department of Agriculture-Forest Service, Department of Interior-National Park Service, Bureau of Sports Fisheries and Wildlife, Bureau of Land Management, Bureau of Reclamation, and Department of Defense-Army Corps of Engineers.

Although other federal agencies influence use of public lands, their primary responsibilities often are not related to land management per se. For example, the Geological Survey surveys, maps and classifies lands as to mineral values and advises land management agencies. (It has, however, a strong relatively independent role on mineral leasing regulations.) The Bureau of Public Roads issues guidelines and approves plans for state and interstate highway design. The Department of Defense and the Atomic Energy Commission use large areas of public land for testing and national defense purposes. The Bureau of Outdoor Recreation coordinates recreation planning. The Department of Housing and Urban Development awards grants for community planning and public facility development. The Soil Conservation Service promotes and gives technical and financial assistance for agriculture planning and development.

These agencies and others influence public land management decisions, but their role is peripheral or emtributory in contrast to the direct planning and management programs of the first group of agencies. Environmental considerations should be important within the special objectives of this second group of agencies, and expertise in this respect should be brought to bear on their influences on public lands. However, in terms of overall, broad-scale environmental quality planning, it is with the six agencies first named that this discussion is mainly concerned.

Levels of Interaction in Federal Lands Management

In general, the federal organization for public land management involves five major levels of interaction:

1. The Congress where major policy goals are authorized;
2. The Executive Office of the President where major policy interpretation is made, where significant new policy recommendations may originate and where major budget decisions are made;
3. The Secretariat and the land managing agency head office where policy is further interpreted, where major agency goals are defined and instructions issued for agency accomplishment;
4. The agency regional office (and in some instances, subregional offices) where instructions from the highest levels are related to regional characteristics and detailed instructions and the method of accomplishment are prepared;
5. The agency unit office (National Forest, State B. L. M. Office, National Park Superintendent Office, etc.) where program elements and instructions are prepared for the field land manager; and
6. The field manager where programs are implemented.

Although policy evolution and policy discussion occur at all levels and the distinction between purely administrative or operational matters are often blurred, an understanding of these levels which are common to public land agencies is useful for analysis and discussion.

How Policy is Communicated

In general, policy articulation from the Congress and the Executive Office flows downward through the organization. However, discussion and debate over new policies, to be meaningful, is dependent upon lines of communication running from lower administrative units upward. The agencies' knowledge of physical resource conditions, the needs of constituent groups and other demands for use of public lands need to be known by the Congress for a meaningful resolution of policy matters; also, for them to be able to evaluate communications they receive from other sources--the lobby groups, interested publics, individual users of public land, etc.

Although the scale of decision making decreases from the Congressional level through the agency organization to the individual land manager, each level makes decisions which influence environmental quality on the public lands. While Congress by enactment of legislation may set the overall policy for activities involving public land management, each agency will interpret their programs within a differing, individual frame of reference. Decisions at all levels within the agency reflect the particular institutional posture or "mission" orientation of those involved.

Injecting Environmental Concerns Into Decision-Making

If environmental quality preservation and enhancement is to be incorporated into public land management, it must become a part of both the planning and decision-making process. The forester or mineral specialist must give the concept attention equivalent to that of the environmental specialist. To accomplish this, it is essential that the resource specialist be involved in the planning process, for preservation of environmental quality.

Public land managers do not make decisions in a static environment. On the contrary, their decisions are made in a highly dynamic situation in spite of the fact that there may be an orderly flow of policy decision at the Congressional level, and a systematic delegation of authority to the land manager. There are diverse and often conflicting pressures bearing on federal decision-makers. The following diagram illustrates common influences confronting the makers of decisions affecting public lands:

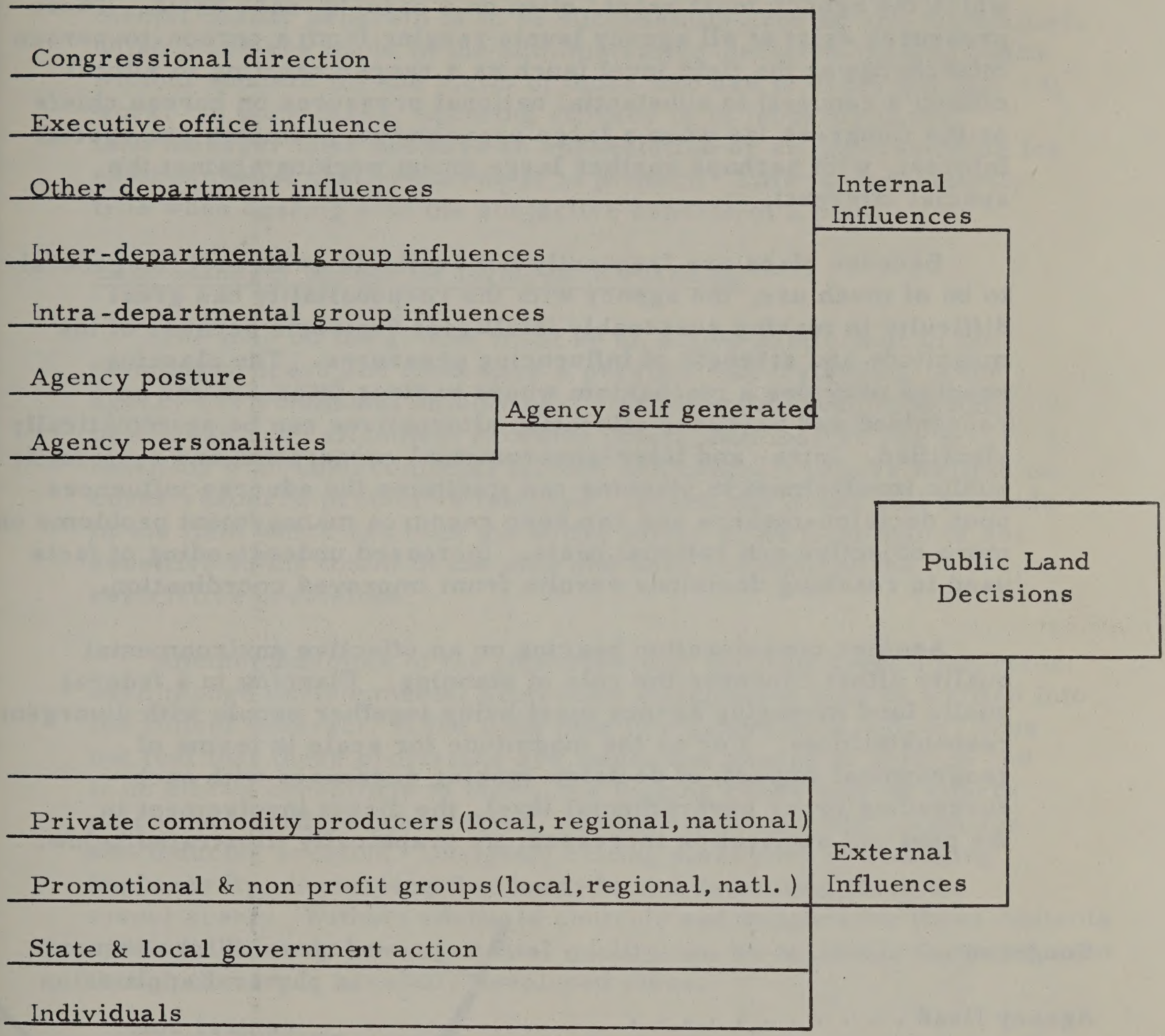

Congressional direction
Executive office influence
Other department influences
Inter-departmental group influences
Intra-departmental group influences
Agency posture
Agency personalities
Agency self generated
Internal Influences
Public Land Decisions
Private commodity producers (local, regional, national)
Promotional & non profit groups (local, regional, natl.)
State & local government action
Individuals
External Influences

Fig. IX. 1

Pressures on Decision-Makers

Frequently these influences take the form of direct pressures to which the agency must react, often on a case-by-case basis. These pressures exist at all agency levels ranging from a person-to-person interchange at the field level (such as a ranger reacting to a local citizen's request) to substantial national pressures on bureau chiefs or the Congress (as when a large organization promotes one special interest, with perhaps another large group working against the special interest).

Because plans are frequently not available or at best too general to be of much use, the agency with the responsibility has great difficulty in making reasonably intelligent decisions because of the magnitude and strength of influencing pressures. The planning process provides a mechanism where various interests can be recognized and resource allocation alternatives can be systematically identified. Intra- and inter-governmental cooperation and systematic public involvement in planning can minimize the adverse influences upon decision-makers and can keep resource management problems on a more objective and rational basis. Increased understanding of facts used in reaching decisions results from improved coordination.

Another consideration bearing on an effective environmental quality effort concerns the role of planning. Planning in a federal public land managing agency must bring together people with divergent responsibilities. For as the magnitude (or scale in terms of geographical impact) of decision-making decreases with each succeeding lower governmental level, the direct involvement in the physical application increases, as graphically illustrated below.

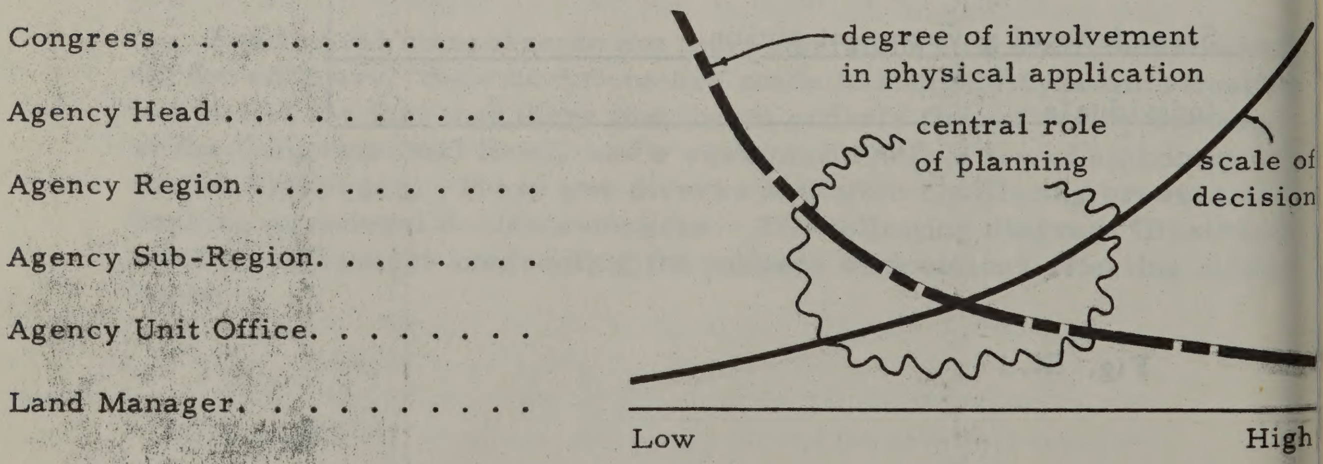

Congress . . . .
Agency Head . . . .
Agency Region . . . .
Agency Sub-Region. . . . .
Agency Unit Office. . . . .
Land Manager. . . . .
degree of involvement
in physical application
central role
of planning
scale of
decision
Low
High

Fig. IX.2

The planning process involving the public lands must address itself to both these aspects of the Federal structure if an environmental quality program is to be successfully created and maintained. Often plans are made in the administrative-decision-making realm without concern for the views of those who are to carry out the work. In such cases, planning efficacy is in jeopardy if the land manager does not have an appreciation or an understanding for environmental quality that he is to protect. This is particularily true when dealing with the subjective aspects of a plan.

Land Manager Should Be Involved in Planning

The man on the ground must be an active participant in the planning process and must have a personal understanding of the agency environmental objectives. For example, even though a particular road alignment crossing public land may be set in harmony with environmental factors and contract papers written to cover resource protective features, certain decisions will be made in the field which can void the entire effort if the field man is not sensitive to the intent of the plan and does not enforce the restrictive provisions.

Another example of the importance of the field level supervisor: even though environmental protection stipulations may be written into the timber contract, if the field man (the contracting officer) does not feel that these provisions are important enough to enforce and if he allows exceptions to them, the logging roads may be poorly placed and crudely constructed, needlessly destroying vegetation and inducing erosion. Unsightly cutting slash may be left lying haphazardly, increasing fire hazards and detracting from the visual scene. Without adequate controls and support for those controls at the field level, environmental quality can be seriously damaged even though there are carefully developed plans.

PLANNING IN LAND MANAGEMENT AGENCIES

Historically, public land management planning has been fragmented and directed toward regional and national economic benefits and/or narrowly defined single purpose objectives. Often, short run decisions are made reflecting those pressures and are not weighed in relation to well conceived long-range plans. Resulting actions are made within the narrow confines of economic and engineering efficiency criteria.

These narrow parameters have been outlined, for example, by Congressional directive which spells out the agency mission or by policy guidance so broadly and ill defined to make the agency purpose difficult to interpret. The Bureau of Land Management is characteristic of the latter, although an interpretation of Congressional and Executive branch policy decisions had led the Bureau to place emphasis either on disposal of public domain or use for economic purposes.

In contrast, parameters for the Corps of Engineers and Bureau of Reclamation planners have been narrowly defined for such purposes as flood control, irrigation, power generation and shoreline protection. Similarly, the Bureau of Sports Fisheries and Wildlife program for national wildlife refuges has focused almost exclusively on waterfowl preservation. Environmental quality preservation has been the prime purpose of the National Park Service, although the new system of national recreation areas, (lakeshores, seashores, wild and scenic rivers, etc.) which places greater emphasis on mass recreation, will strain the capability of planners in that agency to maintain environmental quality.

Environmental Planning Missing on Organizational Charts

In general, agencies have placed internal planning responsibilities in a number of specialized planning units addressing relatively narrow functional purposes -- forest management, engineering, minera resources, grazing, etc. An examination of agency organization charts will seldom reveal the equivalent of a coordination "office of environmental planning". As a consequence, environmental values are seldom given consideration in functional plans. Given this arrangement, each specialty will normally attempt to maximize its influence on land decisions. Normally, the agencies place the bulk of the work for this functional planning in units at the sub-regional or regional level, although they respond to counterpart offices at the Washington level who view the scene from a national point of view.

Intra-Agency Channels of Communication

The function of policy interpretation, defining goals, development of criteria and standards, directives, manual releases and major budget decisions are made at the Washington level by the Bureau chief and his immediate subordinates. Advice on the manner by which each regional function should be carried out is characteristically transmitted through the Bureau chief to the regional chief who in turn interprets and refers such advice to his functional unit. They then communicate their advice to the field land manager through the regional chief.

The provision of functional advice is staff in nature and the task facing the unit manager (national forest supervisor, wildlife refuge manager, etc.) and his field land manager is to interpret and synthesize the advice, directives, regulations and standards and apply them to their planning and their decisions. Seldom does the unit manager have the budget necessary to employ a full complement of specialities to enable him to plan in a comprehensive way for his land management program. At the same time he may not be fully capable of assimilating the information and developing a comprehensive course of action by himself.

Although the above discussion implies a higher degree of organizational rigidity, there are many approved and informal methods of communicating between the field level and manager and functional planning units at each level. In the final analysis, however, it is the field man and those above him in the line who have the responsibility and authority for management decisions.

Single-Purpose Planning and Decision-Making

Patterns of organization tend to reinforce single purpose planning and decision making. The particular purpose which at any point in time is in a favored agency position on which may reflect a short run position of political strength may widely influence land management decisions. The opportunity for weighing short run expediency vs. long range goals and for balancing these influences with a well developed plan may seldom be provided.

When plans are developed they are forwarded to higher authority for approval. These examples illustrate this process in action:

1. Example A: A scenic road planned for a land unit may be planned by civil engineers, perhaps in consultation with landscape architects, the unit manager and field land manager as a part of a total circulation plan for the unit. Engineering standards and criteria developed cooperatively with the Department of Transportation are normally applied

across broad regions and may not fit the specific landscape situation. The plan is forwarded to the regional unit for approval or, depending upon the situation, to Washington for approval and referral back for implementation. The actual implementation may be handled by the field manager through force account, or by contract, or by the engineering planning unit at a higher level.

2. Example B: A timber harvesting plan is evolved by forest management experts in a functional planning unit in consultation with the unit management and field manager. Once approved, the sale is normally handled by the field manager. The timber is advertised, bids let; if necessary logging roads are constructed and the timber is cut.

3. Example C: A camp site plan is evolved by the recreation planners after discussion with unit and field managers and the relevant functional units at the regional level -- landscape architects, engineering, forest management, etc. After approval, the job may be implemented by the field manager with advice and counsel from the recreation planning office.

In all three instances, the standards and criteria and the decision are based on substantial sets of instructions, manual releases and directives which influence the planning and implementation. Engineer standards for each type of road are carefully prescribed -- drainage, cuts, slope, bank stabilization, culverts, bridges, surface, grades, etc. Forest management specialists delineate the approved methods of harvesting each major timber type -- age classes, sizes, silvacultural method, reforestation, slash disposal, etc. Likewise, instructions are followed on the number of camp sites for each campground, tent spacing, vegetation screening, number of toilets, distances from water, type of fireplaces, etc.

The decision to develop in a specific area may be based on a land use map which permits the development or on manual releases which describe various landscape types (crests, flood plains, steep slopes, etc.) and which regulate usage in such zones.

These simplified examples typify a few of the many decisions made by a land management agency. No clear distinction can be made between an areal planning and management form of organization and a functional one. The particular organization form varies from agency to agency. Some follow more closely the functional form wherein the field level manager's role is largely custodial and functional units make the basic decisions, while others delegate more responsibility for coordination and decision making to the field level.

Regardless of the form, functional units in most agencies today have a major influence on what happens on public land, and unless there is a high degree of communication and supervision in the unit office where such plans evolve decisions in the absence of a comprehensive plan for each land use, including an environmental quality preservation plan, may well be at odds with other major land uses. This can be especially true for such uses as protecting of environmental quality where the plan may dictate that nothing be done, or if development is to occur it be accomplished on the basis of plans specific to the site and not promulgated on standards of criteria designed to fit "average" regional situations.

Public Land Agencies and the Public

The quality of the public estate will become increasingly important as public interest in the quality of life becomes more of a public issue. A number of observations can be made regarding these questions and the manner by which public land management agencies can respond to a heightened public interest and awareness:

1. Agency images, public support and progress will become increasingly dependent upon the sensitivity with which an agency manages the environment of the lands under its stewardship.

2. Single purpose plans and functional bias must be dramatically reduced and placed within a context of broader plans. This does not discount the need for specialist assistance. As knowledge of resource management increases, the need for the specialist becomes greater; it is the context within which this skill is placed that becomes important.

3. Short run, politically expedient resource allocation decisions should not compromise carefully developed plans. Irreversible decisions (dams, major roads, etc.) for use of public land must be carefully weighed and when options are available such decisions might well be deferred for further consideration.

4. If environmental quality preservation is a public purpose, agencies oriented towards commodity production will have to shift emphasis and weigh goals other than those which can be quantified in economic terms.

5. Where several land management agencies operate in the same geographical area, agency competition must give way to agency collaboration, and efforts should be joined to plan in concert with each other to protect quality over these larger land units.

6. Although public lands provide a reservoir for public works in times of regional or national economic difficulty such work should be done within the parameter of planning, standards which include environmental quality. Other public works projects which have major impact on natural quality, though they meet the benefit to cost test, might well be dropped after being viewed within a large regional and national environment quality and economic development perspective.

APPLYING ENVIRONMENTAL QUALITY DIMENSIONS IN PLANNING

Preceeding sections have defined environmental quality and the techniques necessary to identify quality in landscapes. To do this, resource data from a wide variety of sources and the special skills and knowledge of specialists in a number of resource disciplines are required -- foresters, geologists, ecologists, archeologists, hydrologists, etc. Upon completion public land management units will have maps which in the first stage of the process identify quality and as more refined data are used, a ranking by priority will be possible. Thus, field managers and functional planning units will eventually have available for reference and for guidance in management decisions a map showing impacts.

High priority areas may well be classified or zoned as "scenic", "scientific", "wilderness", etc. with no commodity production or developmental uses permitted. Standards and criteria for use in areas of lower ranking will recognize intrinsic landscape values and will be modified to minimize impacts and to weigh alternatives.

A preservation of environmental quality does not necessarily mean a dominance of any one resource use nor the exclusion of any particular element. It does mean that the environmental plan can express a way of doing things and a system of controls to insure that valuable environmental resources are not irretrievably damaged, while still permitting use.

Standards of Environmental Quality

Environmental quality criteria standards have been developed by many land management agencies. To command attention at the subordinate planning and decision level, however, it would be necessary to incorporate such regulations into the day to day operations of each functional planning unit at each level of the agency. Separable landscape elements -- forests, water, minerals, etc. -- are functionally planned for in each agency. The environmental quality plan, however, relates each element in the landscape. The composite provides the basic for the synthesis, analysis and identification of quality. Most land management agencies are not presently structured to do this job.

Environmental Inventories

Environmental resource inventories and analyses attempt to locate and to record graphically scenic, landscape and cultural features which until now have been largely considered intangible and aesthetic. They make possible the addition of a new factor of environmental quality to be combined with engineering and economic criteria in the planning and decision-making process. While this broader planning concept is still in its infancy, it is becoming an extremely useful tool to cope with natural and cultural quality in both developmental and conservation planning, Here is a means of expressing visually and quantitatively those values which are seen and sensed but present difficulties in measurement in the traditional terms of the engineer and economist.

"Natural environmental systems" are identified from maps and field reconnaissance of topography, vegetation and water areas. Symbols are added indicating such natural features as wildlife, vegetation, land forms, water areas and water in motion; and such cultural resources as historic, archaeological and modern structural developments. Maps, shadings and colors in addition to other symbols express special features of outstanding or better-than-average quality and worthy of consideration in advance of developmental planning. This new form of environmental resource inventory gives added dimension as an overlay to the existing basic resource inventory maps of soil, topography, land use and cover, water resources, etc.

Environmental Awareness and the Planning Process

There are many ways in which this awareness of environmental quality can measure program impacts and guide the planning process.

Prior to field surveys, planners can employ the information set forth on these maps to evaluate program impacts, to guide their direction and to pinpoint their location. Lacking this graphic description of natural landscape qualities, these concepts have not been attempted in the planning and project decision-making process up to now; but it may be expected that a broader comprehension in application will be possible by imaginative employment of this technique.

The inventory mapping not only identifies outstanding natural "systems" in the planning area, but clearly indicates where present and projected development may well drastically alter environmental quality unless further detailed resource surveys are followed by innovative regional design alternatives.

Development Planning and Design

1. It is possible, following landscape surveys, to guide route location (highways, pipelines, transmission lines, utility transmission lines, etc.) in harmony with identified corridor and to use existing transmission systems. Thus, more use can be made of existing developed corridors and damaging developments in adjacent scenic areas can be avoided.

2. Industrial, urban, recreational and other intensive land use developments can be located in areas where landscape damage and air and water polluted wastes can be diverted or minimized. Residential developments can be fitted into areas of medium natural quality with appropriate taste in design, and proper carrying capacity studies can be completed.

3. Flood plain areas of intensive development with high flood risk needing protection by engineering structures can be delineated separately from undeveloped scenic areas of low flood hazard on which high-cost flood abatement measures are unjustified. The latter can be zoned against development and converted into public recreational and park areas.

4. Water control structures and other water resource developments can be designed to provide minimum environmental disturbance and maximum opportunities for recreational, fish and wildlife, etc.; also compatible commercial uses are possible by using careful design criteria.

Protection and Preservation

On environmental resources inventory maps, certain natural concentrations of especially high quality have been delineated which will require further detailed study and analysis to determine their feasibility for the following types of non-development uses:

1. High-quality, rare, strategic or other special natural, cultural, scenic or archaeological features which deserve special preservation or protection measures: e.g., Indian mounds, virgin forest tracts, prairie remnants.

2. Certain specific areas providing waterfowl nesting wetland, migratory bird flyways, anadromous fish spawning areas, scenic bluffs, freeflowing wild rivers, scenic lakeshores, open spaces near urban concentrations, wilderness and natural areas.

Once such areas have been identified, steps can then be taken during the planning process to protect them and to avoid developmental programs which would alter the character of the particular resource. Thus drainage projects, for example, clothed in watershed conservation plans, would not disturb waterfowl potholes; environmental corridors would not be seized upon as easy routes by highway builders, etc.

Influencing the Decision-Makers

A final and key step required to place this new knowledge into action is to reach and influence the decision-makers so that these additional environmental criteria can be added to engineering efficiency and economic factors before plans become crystallized. Used in the manner described, environmental resource inventories can reduce traditional conflicts between those who would develop and those who would preserve by making clear to each those areas where the values of the other will or will not mesh. And equally important will be to show where and how development can be fitted and designed so as to complement and not violate natural and cultural qualities of an area.

Fundamentals of Environmental Quality Planning

Effective environmental quality planning which will influence the way in which public lands are used should be based on the following premises:

1. Full agreement that a plan is essential to wise stewardship.

2. At no one point in time will there be an environmental quality plan per se. An initial step will include the preparation of a map delineating quality. Over time this will be refined and modified and as new resource knowledge becomes available, it is fed into the system. Also, as we understand more fully mans' needs for pleasing landscapes and mans' perception of those needs, the plan will change. In short, environmental quality planning to be effective must be a continuous ongoing process in the same fashion as road plans, timber management plans, recreation plans, etc.

3. Although the responsibility for the plan has to be vested in one office or in one man (an ecologist, regional landscape architect, etc.), the plan can only evolve with substantial contributions from many resource disciplines. Obviously the specialists have to be committed to the concept.

4. Supervisors in the line organization who make the decisions have to be involved in the process. Full involvement at the field management level is essential with corresponding less involvement at higher levels.

5. Environmental impacts of proposed projects can be analyzed in advance so as to minimize ecological and other disturbances.

6. Proposals for developmental decisions affecting environmental quality must be funneled through the planning system in advance of decisions to proceed.

7. Closer control and supervision over developmental projects and resource extraction are essential to effective application of environmental planning.

Step-by-Step Environmental Planning

Land use planning requires a series of logical steps in which physical facts are combined with social,institutional, economic data for the orderly allocation and management of land into uses consistent with clearly defined goals. Environmental considerations can be interwoven into the planning process as shown by these steps for a given area or unit of land:

1. Interpret policy statement, define goals and relate to management objectives.

2. Inventory (natural and cultural) resources. Detailed techniques are discussed in other portions of these reports. The inventory should also include an analysis of economic and social factors including an identification of institutional constraints. Measure the effects of past and present uses.

3. Analyze and synthesize inventory data which will identify environmental quality.

4. Project probable future uses with an evaluation of these impacts on the environmental quality of the land unit and to provide information for the next step.

5. Allocate land through a land classification system. This will be dependent upon an analysis of present capabilities, an estimate of future uses and a modification of present management practices to fit management goals. Decisions will be made regarding the most effective uses or combinations of uses. For public lands such classification would provide for a range of uses from wilderness and wild rivers, commercial forestry, grazing and intensive recreation lands likely to remain in federal ownership to those likely to shift into other ownerships; i. e., urban influence zones, for example.

6. Synthesize data from management plans for retained lands from steps above for resources in each land use class and include provisions for resource rehabilitation, applied conservation techniques and protection of environmental quality.

7. Develop standards based on technical conservation practices for management of uses; build into each standard new techniques outlined in these reports for preserving, enhancing or restoring environmental quality.

8. Design all new projects within a framework of environmental quality standards.

To assure successful application of the plan on the ground require that future decisions affecting uses of the area (see Table III-1 in Chapter II) be within the prescribed limits of the management plan. To provide for recurring and new needs, plan revisions must maintain basic goals and must be revised in accordance with new policies.

Long Range versus Short Range Plans

Is the environmental quality plan per se a long range or short range plan? In effect it should be both. Policy articulation provides the long range public goals. Likewise, the agency will have translated this policy framework into long term agency objectives and will have modified its management program accordingly. The environmental quality plan will have been developed as the basis of these two steps and will spell out specifically how the task is to be performed over the long run. Furthermore, there should be an analysis of the manner whereby short run decisions influence the long run objectives. Annual budgets are the single most important step in making short run decisions which influence long run plans.

Agency Administration Must Include Planning

Although other chapters discuss various organizational approaches to environmental quality planning, it is relevant to note at this point that the planning has to be an inherent part of an agency administrative effort. The planning function and the operations function must be tied closely together. "Central planning" completely divorced from operations may lead the operations branch personnel to actively resist any effort to influence what they construe to be their responsibility (and indeed operations branches must plan). Likewise, to place a central planning unit at a higher level in the organization heirarchy to whom operations branches forward their plans for review, comment and approval may lead to serious antagonisms and seriously weaken even the best of plans.

The two functions--planning and operations--should not be two disperate efforts for neither will succeed in preserving or enhancing environmental quality. The budget process, too, has to be tied to the planning process. If agency planners do not work closely with budget officers, their plans will not be translated into short run decisions which determine the long range plan accomplishment.

ORGANIZATIONAL STRUCTURE

The preceding discussion of weaknesses of functional planning typical of the public land management agencies provides further support to the conclusion that organizational modification is likely to provide effectively for environmental preservation and improvement on the public lands. Adoption of the interdisciplinary team planning approach emphasized in preceding chapters of this report is also a mandate for organizational restructuring in most of the land management agencies. One land managing agency presently structured for a team planning effort is the National Park Service.

"Internal" Structure

In visualizing alternative planning organizational possibilities, two major systems are apparent. One can be termed the "internal structure" and represents planning for agency resource programs by agency personnel. This is the system most commonly used by the public land managing agencies. It is a logical approach for ongoing, dynamic planning problems because the planners can work in the same frame of reference for extended periods and become intimately involved in agency policies and goals. However, an internal planning unit has some inherent disadvantages such as a tendency to become stereo-typed following their traditional planning solutions and to resist innovation and new concepts. The trend toward "this is the way we have always done it" is strong with an internal planning unit, particularly if staffed by older, long-term employees.

"External" Structure

A second system for planning can be called the "external structur and provides for planning by consultants (either public service agencies universities, or private firms, and individuals) outside of the agency. Consultants are most commonly used by an agency to provide information and plans that the agency cannot provide with its own staff. Inter-agency consulting is important, particularly to public land development activities. For example, the Bureau of Reclamation has a high internal capability for irrigation planning, but must rely almost completely on the Bureau of Outdoor Recreation for recreation evaluations, the National Park Service for recreation plans, the Fish and Wildlife Service for wildlife advice and the Corps of Engineers for flood control material. Other agencies rely on this type of interchange also. Some federal inter-agency consulting is mandatory under Congressional directives such as the Fish and Wildlife Coordination Act.

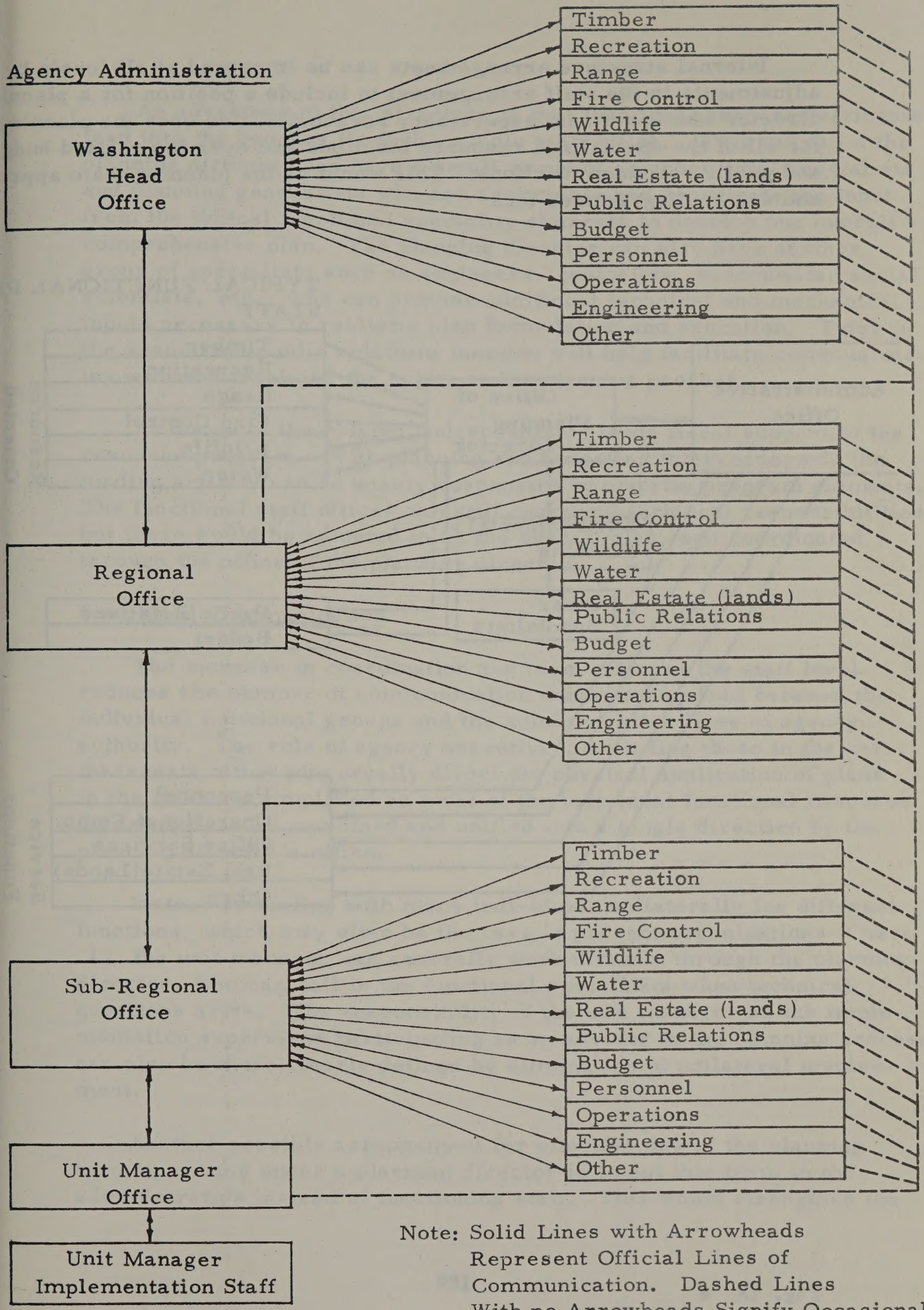
Private consultants are also used by the land managing agencies, under contract arrangements, particularly to lend an air of objectivity and fresh thought to a special resource planning or design problem. Planning under private consultant contract is often difficult and inefficient for long-range, complex management activities, but sometimes works very well for short-term planning with carefully defined objectives.

Functional Planning Organization

A number of organizational charts can be set out using either the "internal" or the "external" system, or a combination of the two systems.

The following diagram represents a typical organization of the "internal" type, common in some of the federal public land management agencies today. As can be seen from the diagram, each resource element is an individual, co-equal staff function interacting more or less independently with the agency administration. Overall program coordination and comprehensive resource planning is deficient at the staff position and, if carried out, must be picked up by the agency executives, who often have neither the time nor the broad technical background to monitor the individual functional activities who may have to decide difficult program conflicts arising from poor interdisciplinary staff coordination.

Chart # 1 Common Functional Staffs



Note: Solid Lines with Arrowheads Represent Official Lines of Communication. Dashed Lines With no Arrowheads Signify Occasional Informal Coordination by Individual Functional Staff Units.

Fig. IX. 3

Internal structure arrangements can be improved at all levels by adjustments in the staff arrangement to include a position for a planning director who has direct supervisory responsibilities over the planning for all of the specialized resource functions and over the related budget and public relations functions. This would be the planning team approac and can be diagrammed thus:

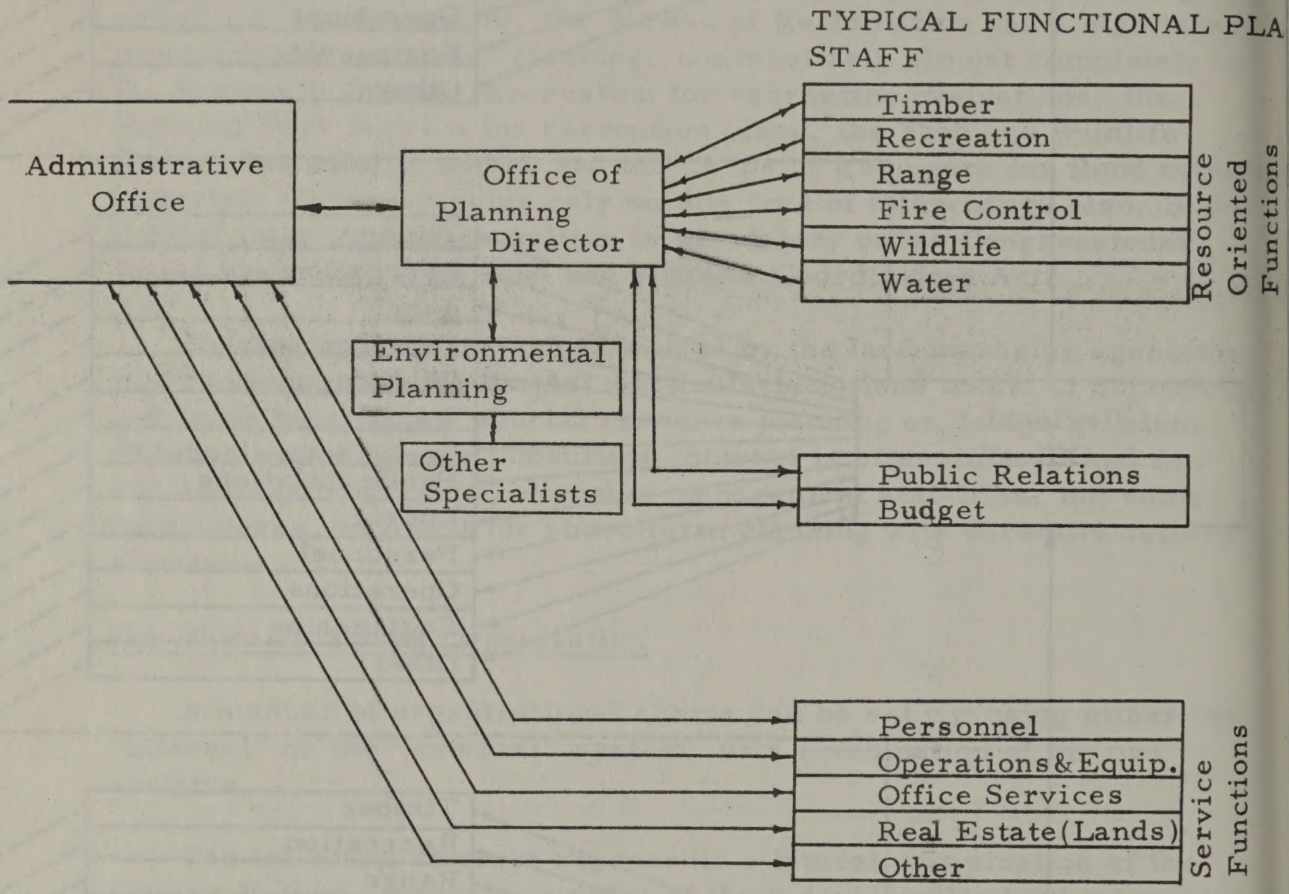


Fig. IX. 4

An advantage to this structure is that functional resource elements feed into the process through a single staff office. This office (of the planning director) can have a small group of environmental specialists and planning generalists who can assimulate and coordinate the input from the typical functional speciality elements to develop one overall comprehensive plan. The planning director can also have another group of specialists such as engineers, geologists, economists, social scientists, etc., who can provide additional technical and mechanical inputs necessary in realistic plan formulation and execution. Tying in the associated public relations function will help facilitate communicating with and involving the public in the planning process.

Inclusion of the related budget function lends fiscal support to the resource program. With planning and budgeting interconnected, the funding activity can be wisely responsive to priority program elements. The functional staff offices can still carry out technical responsibilities but these would be adjusted to fit the overall plan, and coordinated through the office of the planning director.

Simplified Communication

The increase in coordination and team effort at the staff level reduces the number of communication contacts required between the individual functional groups and the administrative lines of agency authority. The role of agency executives, including those in the unit manager's office who usually direct the physical application of plans in the field, is simplified as most of the individual functional resource directives can be combined and unified into a single directive by the planning director's office.

Instead of dealing with many individuals unilaterally for different functions, which may often be the case in present organizations (Chart 1), the unit manager can generally work directly through the planning director, who can call in the functional specialists when technical questions arise. The responsibility of the unit manager as the implementation supervisor participating as an advisor in the planning process can also be more clearly defined by elimination of unilateral involvement.

Another possible arrangement for effective use of the planning team operating under a planning director is to put this team in the administrative instead of functioning staff. This would strengthen the planning process and particularly the role of the planning director in the decision-making process. The planning directors, supported by teams of resource specialists, would have a voice of authority in agency policy formulation and program goals at the various administrative levels. Instead of acting in more or less an advisory capacity to agency administrators from a staff position, planning directors could directly influence the character of agency involvement in comprehensive resource activities.

The planning office would in a sense also have a supervisory role in plan implementation at subordinate levels. Also since the planning function in the administrative line issues directives with this supervisory authority, participation in the planning process by the subordinate unit manager is not as crucial for implementation continuity as it is when planning is a staff function. With planning in the supervisory role, the unit manager could become essentially an implementor concerned solely with the mechanics of getting the management job carried out, referring nearly all basic decisions back up the line directly to the planning office.

In-Line Planning Organization

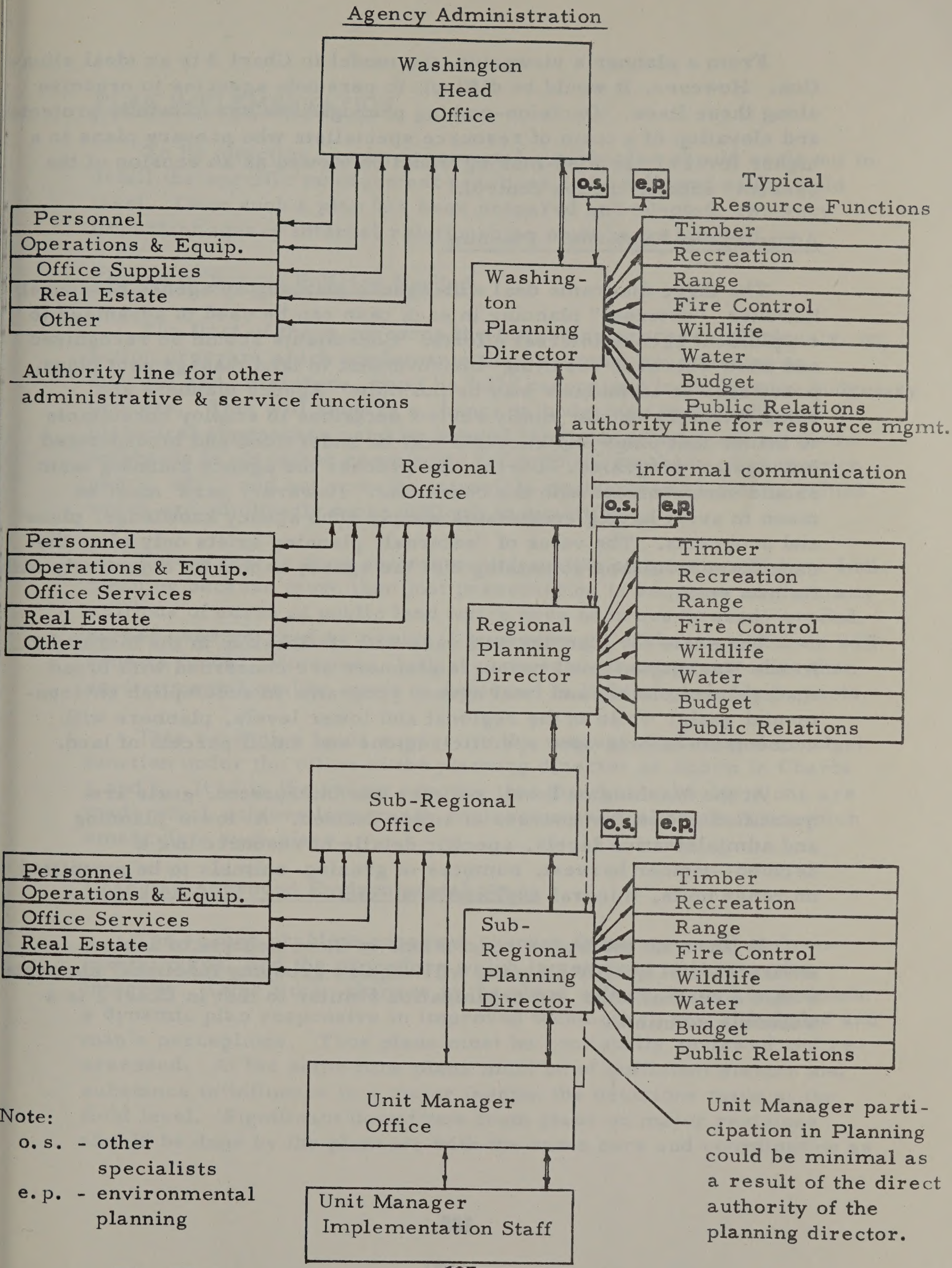
A diagram for an in-line type of planning organization is shown on the next page.

With this organizational model, the budget function and the public relations function could be incorporated in the planning process under the planning director, the same as in Chart on the proceeding page 184. This would even further strengthen the role of the planning office within the agency organization. To provide some balance of authority, agency administrators may wish to keep particularly the budget function as a staff element separated from the planning group.

Decentralized Decision-Making

Public land managing agencies in some instances have made a conscientious effort to decentralize decision-making responsibility. To have decisions made at the lowest level of administration as possible has been the goal. In keeping with this, unit management offices have been delegated a good deal of decision-making authority. An organizational restructuring to the model in Chart 3 would redelegate much of the unit manager decision responsibility to the planning function and in this respect counteract the present effort toward decentralization.

Chart # 3



Unit Manager participation in Planning could be minimal as a result of the direct authority of the planning director.

Note:
o. s. - other specialists
e. p. - environmental planning

Fig. IX. 5

From a planner's viewpoint, the model in Chart 3 is an ideal situation. However, it would be difficult to persuade agencies to organize along these lines. Decision-making prerogatives are carefully protected and elevation of a team of resource specialists who prepare plans to a higher level of decision-making would be viewed as an erosion of the present administrative control.

Advantage of "External" Planning

The three diagrams deal with agency planning by agency personnel; however, "external" planning in each case can be used to advantage to supplement agency internal efforts. Consultants should be recognized and used wherever resulting improvement in land management plans, practices, or techniques may be possible. Agency planners and administrators should jointly review decisions to employ consultants to insure that plans and concepts will be understood and incorporated into agency programs. During the process the agency planning team should communicate with the consultant. However, care must be taken to avoid having consultants simply echo agency knowledge, plans and programs. The value of "external" planning exists only when the consultant furnishes something that the agency cannot do objectively with its own staff.

The scale for planning will vary with its location in the hierarchy. At the Washington level resource planners are concerned with broad management effects and total agency programs to accomplish environmental goals, while at the regional and lower levels, planners will concentrate efforts upon specific regions and small parcels of land.

At the Washington level, policies are interpreted, goals are quantified and major courses of action defined. At lower planning and administrative levels, specific details of resource use a decided--timber harvest, numbers of grazing animals to be permitted on range units, mineral exploitations, etc.

In line with the major conclusions in these reports,to achieve environmental quality planning will require grouping functional elements within a central unit. An organization similar to that in Chart 2 is a workable solution.

PLAN IMPLEMENTATION

To be effective, an environmental quality plan should spell out in detail the specific management practices to be followed at the field level. Once such a plan has been prepared and adopted, two very important agency internal relationships must be maintained.

Change in Budget Policies Needed

The first of these concerns the budgetary process. Obviously, an action program which implements the plan must have funding to succeed and, therefore, must be fully recognized in the agency budgetary process. This will require a change in budgetary philosophy and historical approaches used by federal land managing agencies where emphasis is placed on commodity production, numbers of recreation users, etc., and not upon the intangible environmental quality values which are admittedly more difficult to quantify.

Unless this is done environmental quality programs will have little meaning because more than just preservation is required on the many millions of acres of public land which have been overgrazed, eroded, burned and scarred by mining. Improvement of these conditions will require funds. Moreover, budget proposals for purposes other than environmental quality must be reviewed in light of probable impacts.

This reasoning lends support to the concept of placing the budget function under the office of the planning director as shown in Charts 2 and 3. It is in the budget process that the short-run decisions are made which achieve long-range environmental quality plans or which emasculate such plans.

Changing Approved Environmental Plans

The second problem concerns changes from approved environmental plans, and the procedure which is required to insure plan integrity. Over time, changes in the plans will be needed to maintain a dynamic plan responsive to improved techniques, new knowledge and man's perceptions. Thus plans must be continually reviewed and reassessed. At the same time plans must be of sufficient stature and substance to influence in a major fashion the decisions made at the field level. Significant deviations from plans or major revisions should be done by the planners with the same care and coordination as the initial effort. Field unit managers should not be allowed to make changes as this will seriously weaken the strength of the plan. Field managers are often subject to heavy local influencing pressures and may not be able to maintain an appreciation for broad, overall long-range values inherent in the environmental plan. To prevent deterioration of the plan quality, scheduled periodic reviews should be establish by the agency, and a formalized procedure agreed to whereby substanti changes in plans are reviewed and approved. Regular field inspection of results acts to support high standards. An amendment process migh be as follows:

CHART 4

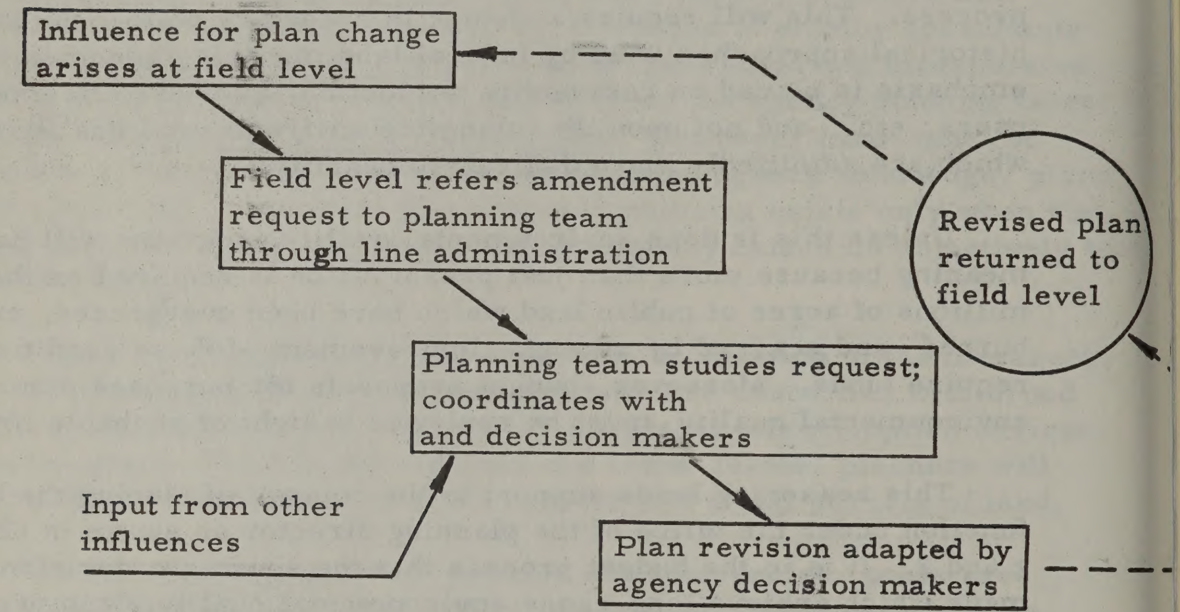

Influence for plan change arises at field level
Field level refers amendment request to planning team through line administration
Planning team studies request; coordinates with and decision makers
Input from other influences
Plan revision adapted by agency decision makers
Revised plan returned to field level

Fig. IX.6

Such a procedure prevents erosion of the plan at the field level and also gives specific "higher level" support to the field agent who must implement the plan.

APPENDIX to

Section A

APPENDIX INTRODUCTION

Excluding Appendix A., Appendices B. through E. of this report offer brief insights into research being conducted in the Environmental Awareness Center at the University of Wisconsin. This Center, under Director Philip H. Lewis, Jr., is the functioning "research-arm" of the Department of Landscape Architecture. Within the Department's graduate program, numerous undergraduate and graduate fields are available to the Center for research under team-directed efforts.

In a serious attempt to refine "subjective" value approaches to environmental quality through planning and design, the Center is currently utilizing talent from air photo interpretation, architecture, art, computer science, engineering, forestry, geography, history, journalism, landscape architecture, psychology, soil science, and urban and regional planning.

APPENDICES CONTENTS

APPENDIX A.	"Identifying Human Impact," an introduction to Prince Phillip's "The Countryside in 1970" conference report, detailing human impact characteristics.
APPENDIX B.	Abstracts the current research of Prof. Atef Sharkawy in which he is attempting to construct a workable multi-disciplinary team approach for comprehensive inventory, analysis and synthesis in the environmental planning and design fields.
APPENDIX C.	Abstracts the current research of Prof. Bruce Murray who is evolving a better technique for measuring public attitudes toward various physical surroundings.
APPENDIX D.	Abstracts the current research of the Environmental Awareness Center in developing an extensive environmental variable matrix that can be utilized in the Steinitz-Rogers Computer Program. The current study will offer environmental guidelines for the alignment of the new interstate highway from Milwaukee to Green Bay, Wisconsin. Although too early to report in detail at this time, Appendix D. also includes a resource sensor matrix that is being developed by Prof. Ben Niemann, Prof. Ralph Kiefer and graduate student Mike McCarthy. Under research contracts with NASA, this team is identifying ways in which critical environmental variables can quickly be recorded and kept current by remote sensing techniques. When dealing with regional and national resource values, these new techniques can prove to be invaluable to new national planning and design programs.
APPENDIX E.	Includes five maps of Alaska, demonstrating the Landscapes Inc. and Environmental Awareness' first approximation approach, that can be conducted over large areas within a relatively short time. More detailed studies have now been completed by Landscapes Inc. staff for Wisconsin, the Upper Mississippi Valley and the Great Lakes Basin.

APPENDIX A.

"IDENTIFYING HUMAN IMPACT," PRINCE PHILLIP'S "THE COUNTRYSIDE IN 1970" CONFERENCE REPORT

(EXCERPTS)

Scope And Objects

While many discussions and analyses have been made of various parts of the problem of human impacts on the countryside, it appears that no really comprehensive list and description is available. The need for such a list has only emerged recently. In this crowded country now every impact has repercussions directly or indirectly on some or many other interests which need increasingly to be compiled in neutral and strictly objective terms, and a genuine attempt has been made to approach this ideal here. It is plain, however, that only partial success has been achieved towards that end. Among the reasons are:

(a) Pending the desired replacement of propogandist and partisan by scientific and generally accepted attitudes to the problem no compilation can be free of bias. This is bound up partly with the character and origins of the source material and partly with the standpoint of the compilers.

(b) Also, although it seems useful to catalogue and analyse the apparent repercussions of man on his environment, we do not know enough to be sure that we can do this fully and accurately in the present state of knowledge, nor is it absolutely safe to assume that a hard and fast boundary line can be found for such an attempt.

(c) Logically, the process of transfer from rural to urban types of land-use and the subsequent history of urban land allocation and land management might well be regarded as part of the subject. In practice this would lead to impossible complications, at least at this stage, and consideration is therefore limited to land which retains a substantially rural character or forms an essential part of a rural landscape, as distinct from land which is effectively transferred and separated from rural use. Account is, however, taken of the repercussions on a neighborhood of encroachment by various forms of building in the countryside.

(d) The range of information marshalled. . . could be presented in several alternative ways. For example, instead of basing it on human activities . . . it might be based on their various areas of impact, or the nature of their impact, or on other factors. The particular arrangement here adopted is designed to enable those engaged or interested in particular activities to trace the repercussions of those activities and their relationship to others. It thus departs from the more usual pattern of looking at particular areas, or types of area, and considering the types of impact to which these are exposed and the sources from which they originate. This approach, while perhaps more natural and convenient for conservationists is less adapted to the working out of a constructive approach by industrial and other managements and administrators.

(e) Some of the activities and impacts which appear significant either as illustrating important principles or for historical or other special reasons, are on a very small scale or may even be dying out. Other wilderness areas would follow at this end of the spectrum.

It is not, at present, thought possible to produce any more satisfactory general classification of activities, but, like all general classifications, this has many imperfections.

Activity Or Operation

This heading roughly corresponds to, but is wider than, a classification of industries and occupations, many of which have as such no impact on the countryside, while many non-gainful activities must be taken into account here. The sub-headings are designed to indicate in some detail which particular operations or processes are mainly concerned, especially where different organizations, interests, or groups may be involved. The aim is to answer the question which are the groups or organizations, or interests, responsible for the various impacts on the countryside.

Area Or Land-Type Affected

The entry here may either specify a particular type of habitat (e. g. arable land, rivets or sea coast) or a region or district or some wide land-use category. The object is to indicate the broad types and locations of land affected, and to show whether these are exposed to more than one impact, thus defining where the most vulnerable points are.

Nature Of Effects Arising

This heading indicates how the activity indicated actually makes its impact on the countryside, and what is the character of this impact. Some of these activities (e. g. fox-hunting or land drainage) are more or less wholly directed to making such an impact, although they may have indirect effects also. Others such as bulk movement of oil may cause serious impacts only in case of accident. Others cause impact incidentally, either knowingly, for instance through emitting effluents of smoke, or unknowingly, for instance, by disturbing shy animals or triggering off subsequent soil erosion, or by the indirect effects of toxic chemicals used with some other purpose in mind. The object... is to enable indirect or unintentional impacts to be traced or kept in mind as effectively as the more obvious and deliberate impacts, and to provide a breakdown of the various types of impacts so that their causes and context can readily be followed through.

Incidence - Time, Space, Degree

This heading is designed to bring out the differences between the various impacts, according to whether they are repeated at particular seasons of the year or times of day, or are once for all (e. g. quarrying), or continuous all the year round (e. g. pollution from a works continuously operated). Similarly, in terms of space, some impacts are universal and pervasive (e. g. radioactive fallout) while others are limited to certain regions or localities... or to the sites or surroundings of particular projects or events. Some occur on a small or medium scale; others are massive and affect large areas and large interests in terms of capital, or numbers of persons involved. Some are essentially ephemeral or dictated by fashion and other short-term considerations; others are long term or permanent. Some are progressive, passing through a series of definable phases, while others are uniform and unchanging. Some also are self-contained and limited, while others may have extensive and continuing side effects or indirect repercussions. Some are entirely or largely incompatible with other interests or involve drastic and irreversible changes, while others are plastic and can readily be dovetailed in with concurrent uses. As it is not possible to deal with all these factors for each of the listed items, the entries must be taken...

as illustrative and intentionally incomplete. The object here is to aid in visualizing the extent and character of the range of variation in the circumstances surrounding the various impacts, and thus to compensate for any oversimplifying impressions which may be derived from the first three columns.

Some Parties Interested

By implication at least activity or operation indicates the party actually responsible for each impact. This heading aims to particularize this information, and to supplement it by adding other parties interested either as suppliers or consumers, or as potentially objecting or opposing interests or in other ways. Such lists cannot, however, be complete or exhaustive and should on no account be taken as implying that other parties not mentioned may not also need to be consulted in numerous cases. The aim is not to define which parties have a status in relation to any particular item, but to provide the user...as a whole with a broad conspectus of the different combinations and recombinations of interest groups which arise in relation to different impacts, and which need to be taken into account, for example, in considering broad issues of organization and public relations.

Examples Of Problems And Possible Solutions

Having roughly classified the full range of human impacts in terms of the activities or operations leading to them, the areas, localities, periods, etc., in which they occur, and the means by which they make themselves felt, and the parties interested in each category, it remains to indicate, wherever possible, examples (preferably published or described by papers in readily available form), to illustrate the problems in more detail. Such illustrations can be of various types, the most frequent being descriptions or discussions of particular leading cases (such as reports of public inquiries) or accounts of actual remedial action which has been proposed or, better still, put into practice and found to provide some solution. Very often those who become involved in some investigation, controversy or project in some part of this vast field are unaware of the existence of earlier cases which would prove helpful for their guidance, or find the task of tracing them laborious and time consuming. By referring, however briefly, to particular relevant cases or situations, it is hoped not only to assist at these points, but to show how by a growth of "case-law" and improved information services the process of resolving differences or clarifying obscurities might be assisted.

Conclusion

It is hoped that in the light of what has been said the right use and the value of the information obtained will become plain. It is, of course, only a first interim key to a vast and complex problem but it can help both to make clear the structure and main features of the problem and to show a way through the wood to those whom might otherwise be lost in it. While the information can supplement and illuminate the use of existing more detailed sources, it in no way replaces them, and a caution must be given against placing on it more detailed reliance than is intended. It is a tool for overall survey, for tracing relationships and for putting particular impacts or other factors in perspective. It is not to be taken as giving answers to be acted on without further reference or reflection.

One of the broad points which seems to emerge... is the very heterogeneous nature of the activities and operations responsible for impacts on the countryside, and the apparent lack of awareness among those concerned of their role in this respect. Those whom Dr. Bracey in "Industry and the Countryside" has named the Guardians of Amenity are themselves a miscellaneous band, but they are all aware of a common interest, whereas those whose activities alarm or antagonize them often have no links with one another, or even recognition of one another's existence. Admittedly they tend to have little in common, and their interests may often conflict, but if they could learn to look on themselves as jointly and generally having some responsibility for the rate, duration and character of changes in our countryside, they would not only help in conservation and preservation, but might find more effective existing experience is indicated...: the time has come to digest it and recognize its wider significance so that more sophisticated and mutually acceptable solutions can be found for problems which currently involve needless loss of time, temper and money. It is hoped that, aided by this analysis, the Study Conference may achieve a better perspective and thus be able to develop more and better ways of reconciling the use of the countryside with its conservation.

APPENDIX B.

A SYSTEM APPROACH TO ENVIRONMENTAL DESIGN

The multitude of conflicts arising between man's actions and the processes of his natural environment reflect the 19th century technique he follows in developing that environment; as fragmentary and centralist such a technique is.

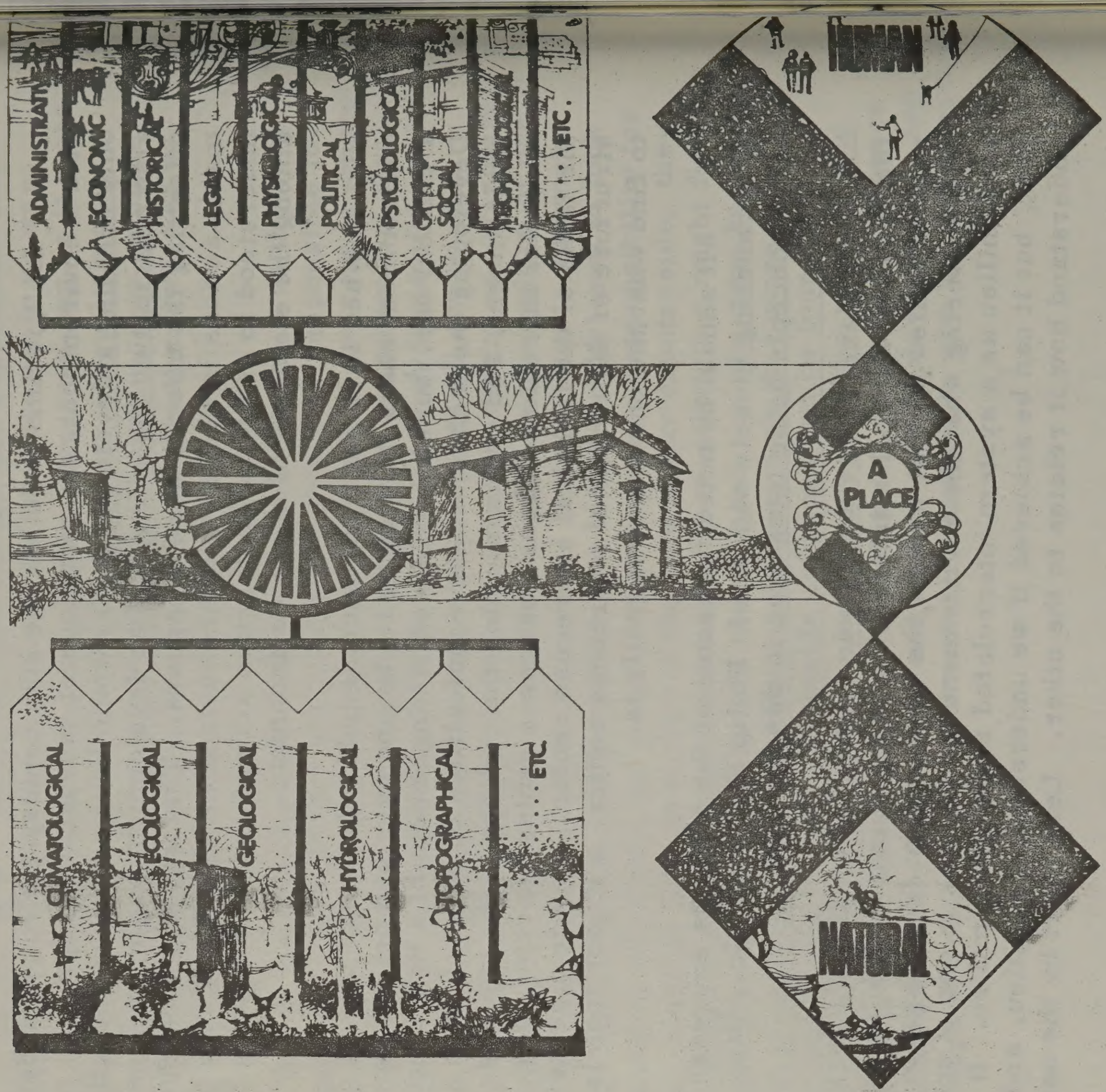
Isn't it time to follow the 20th century technique in developing man's environment, the technique of "suspended judgment"; namely not only creating a development that would have a required function, but also anticipating the effect of that development on the environment and offsetting the effect before it happens. That way the consequences of man's actions in dealing with his environment could be anticipated and understood to avoid the destructive actions and/or retaining the balance among the elements of man's environment.

When it comes to developing public land, the task of creating an environment characterized by its harmonious balance becomes not only a critical one, but also an essential ingredient of a new concept. Developing the technique and technicalities of creating such an environment, and communicating the concept to the public are essential ingredients of the awareness center concept. These are the tasks of the technical awareness center. Before discussing the structure of the technical awareness center, a closer look is necessary to find what the environment really is.

It should be noted that some of the concepts expressed here stem from working closely with Prof. Philip H. Lewis, Jr. with some of his many concepts being integrated in this approach.

A place--large as a whole region, or small as a backyard--is the result of a complex integration of the human milieu introduced to a natural milieu in what we call the environment (see diagram on page **205**). In discovering what the environment is, the task is one of understanding each milieu as a system interrelated to the other milieu. It is a complex task, but it can be achieved if we understand one milieu, and proceed to understand how it relates to the other. Let's start by the natural milieu.

The natural features of a place represent a response to timeless processes that originate from the geology of that place, and culminate in



Printed by permission from: "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 4.

the existing patterns of topography, soils, climate, vegetation and wildlife. The GEOLOGY of a place results from the tectonic forces, diastrophism and volcanism, and/or from gradational forces, degradational or aggradational, working on the earth's crust in a complex manner. The same processes produce TOPOGRAPHY. Geology and topography are interrelated. The topography of a place not only depends upon the forces exerted on that place, but also on the geology of that place and its CLIMATE. Climate and geology can be invoked to interpret current configuration of a place. Climate, geology and topography are intimately interrelated. The three together produce the WATER REGIMEN. The pattern and distribution of rivers and aquifers are directly consequential upon geology, topography and climate. The four elements are closely interrelated. Together they determine the VEGETATION of a place. The distribution quantity, and quality of constituent plant communities in a place are directly determined by the interactions among the geology, topography, climate and the water regimen of that place.

The five subsystems of the natural milieu--geology and soils, topography, climate, water regimen, and plant and wildlife ecology--are intricately interrelated. Their interrelationships keep the balance of the natural milieu. Man cannot overtax one of these subsystems except at a cost to the others and to the total system. To develop an environment, the technical inputs about those subsystems and their interrelationships are necessary. The structure of the technical awareness center should include a natural and physical science team that can provide the inputs and answers regarding the natural milieu.

Unlike the natural milieu that is systematic in essence with more or less a constant pattern of interrelationships following certain laws, the human milieu has a highly evolving pattern of interrelationships which in their turn are constantly changing with time. Yet, the inputs necessary for understanding the human milieu could be covered in two categories:

1. Behavioral: including the sociological, psychological, and medical sub-categories.

2. Implementational: including the economic, legal, political, administrative and managerial sub-categories.

To develop an environment, the technical inputs about those sub-categories and their interrelationships are necessary. The structure of the technical awareness center should include a behavioral team and implementational team that can provide the inputs and answers regarding the human milieu.

The behavioral and implementational teams, and the natural and physical science team provide the inputs and answers regarding the environment--both the human and natural milieus--to the design team that can create the final design in lively forms and spaces. The design team includes the architect, the landscape architect, the engineer and the physical planner. The diagram on page **208** shows the structure of the technical awareness center--a multi-disciplinary structure along the lines defined originally by Philip Lewis.

After framing the structure of the Technical Awareness Center (TAC), we can discuss the process of design for developing public land in an environment characterized by its harmonious balance. The term "design" is considered to include the entire question of demand and the resolution of demand relative to supply, including the capacity of the society or institution to realize its objectives.

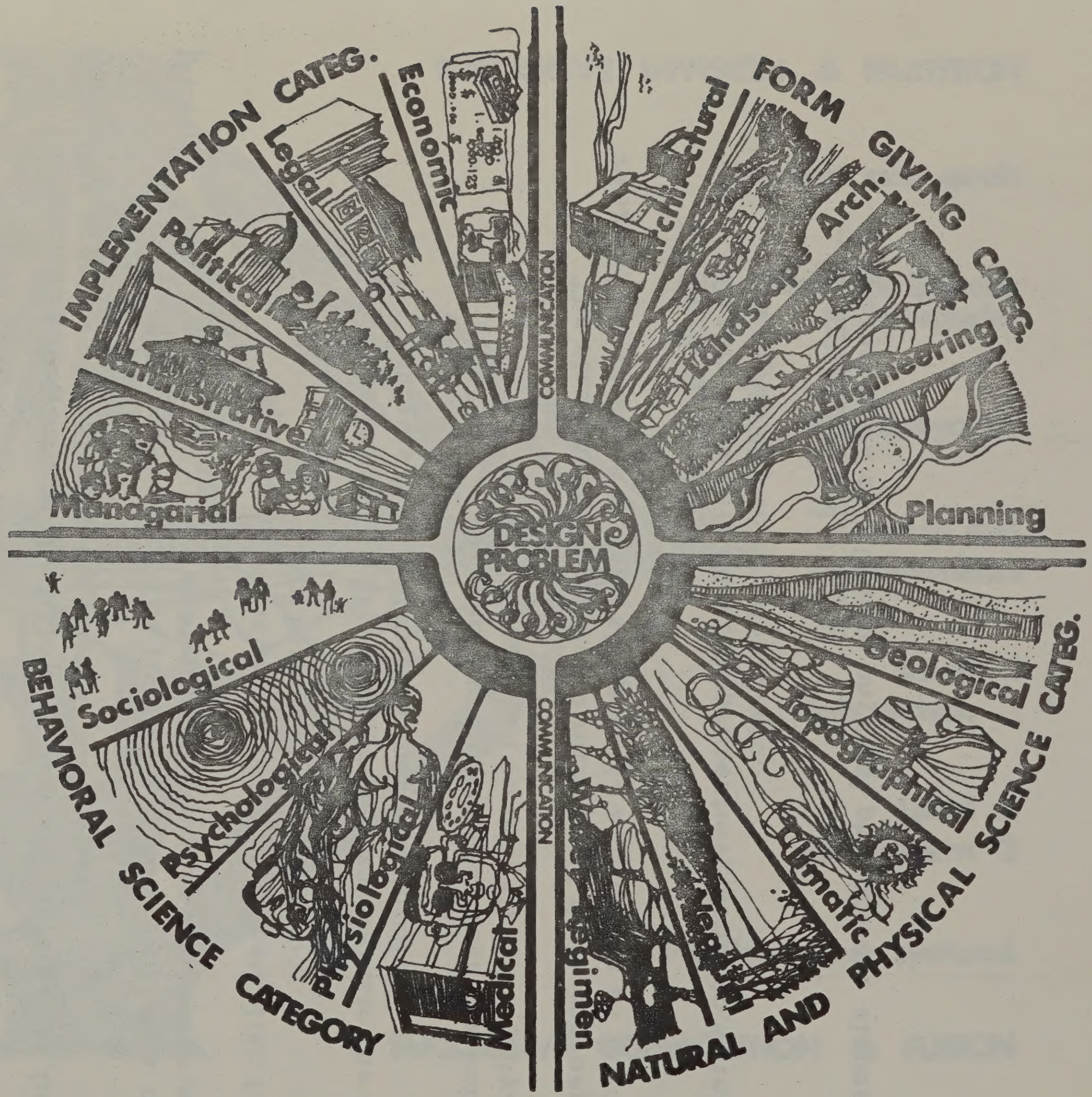
The process of design discussed in this Appendix is a summary of a study entitled "Towards An Environmental Approach To Design, Rationalization In Environmental Design" by M. Atef Sharkawy. Following is the summary of this study.

The use of a systems approach is the keystone in the methodology developed in this study. The reason for using the system as an analytical tool for design is that the elements can be as various as they need be, and not have to be restricted to requirements which can be expressed in quantifiable form. As mentioned earlier, a place is the result of a complex integration of the human milieu introduced to a natural milieu. Considering each milieu a system, the design approach analyzes each milieu separately following one method; that of successive division and partition, then successive composition and fusion.

Very briefly, the steps of the process of analyzing the human milieu are:

1. The first step is to establish a set of goals and objectives.

THE MULTIDISCIPLINARY CATEGORIES



Printed by permission from: "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 22.

Programming

2. The second step is to establish a requirement diagram.
3. The third step is to establish a form diagram.

4. The fourth step is to establish a topological diagram.

A topological diagram is the apex of a set of smaller diagrams explaining both quantitatively and qualitatively the subsystems of a design problem--connected together by the connective movement systems. The quantitative aspect is fulfilled by proportionate diagramming of the subsystems of a project derived from performance standards. The qualitative aspect is fulfilled through indicating the criteria and requirements of design on the diagram--given by the multi-disciplinary team of the TAC.

The diagram on the following page **210** explains the four steps in the process of analyzing the natural milieu are:

1. The first step is to collect data relevant to the design requirements and criteria.

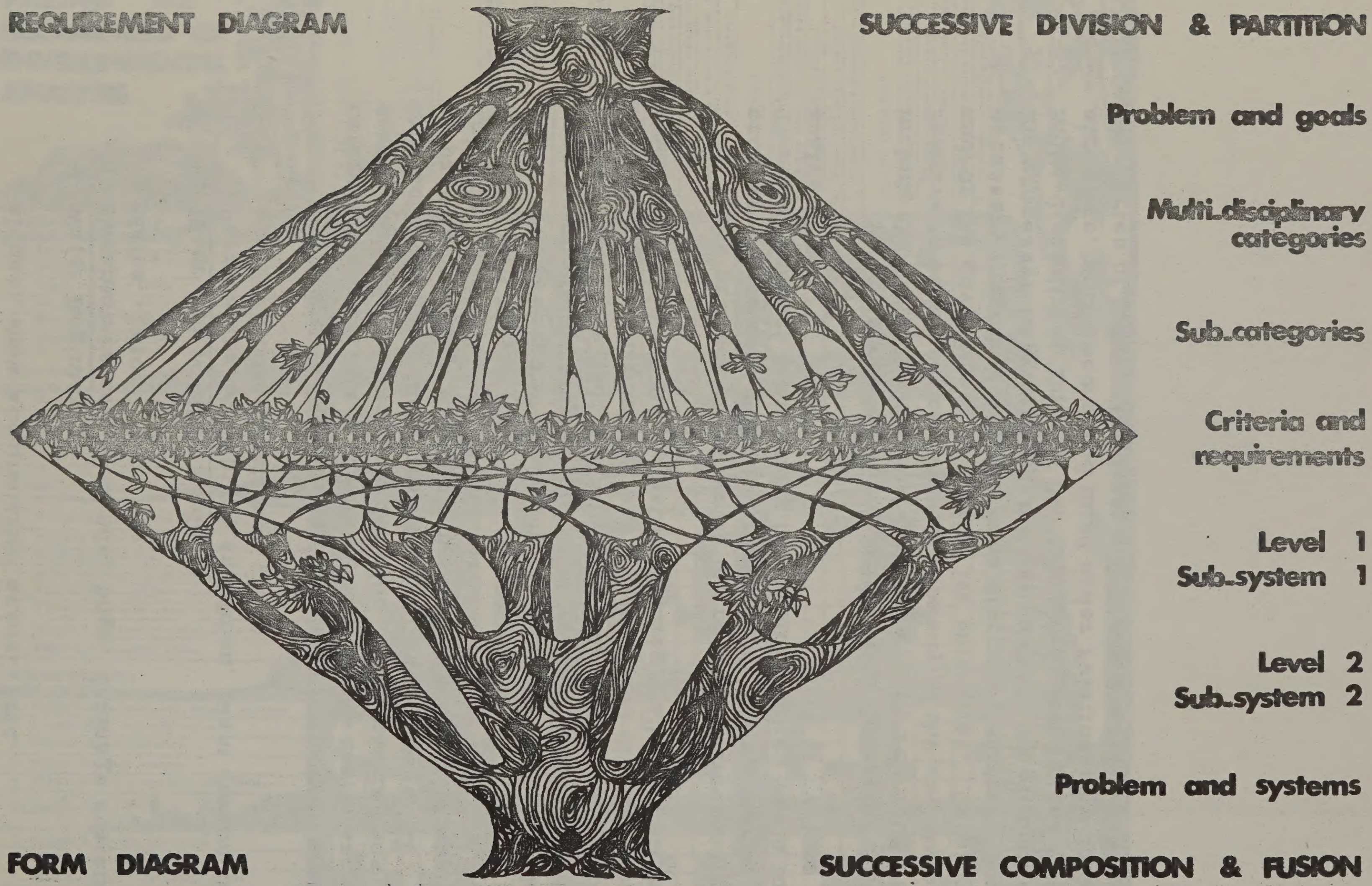
Environmental Analysis

2. The second step is to establish formal parameters of analysis.
3. The third step is to evaluate the five natural elements into suitabilities.
4. The fourth step is to fuse the suitabilities together in an overall suitability.

The elements of the natural milieu and their corresponding range of parameters of analysis (step 2. above) are as follows:

1. Geology And Soils:
   Parameters as: Physical properties, depth to water table, susceptibility to erosion... etc.

2. Topography And Slopes:
   Parameters as: Unique physical phenomena, slopes, views... etc.



Printed by permission from: "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 28.

3. Climate:
   Parameters as: Fog and frost pockets, shadow zones, warm slopes, snow accumulation areas... etc.

4. Water Regimen:
   Parameters as: Wetlands, bogs, drainage systems, flood plains... etc.

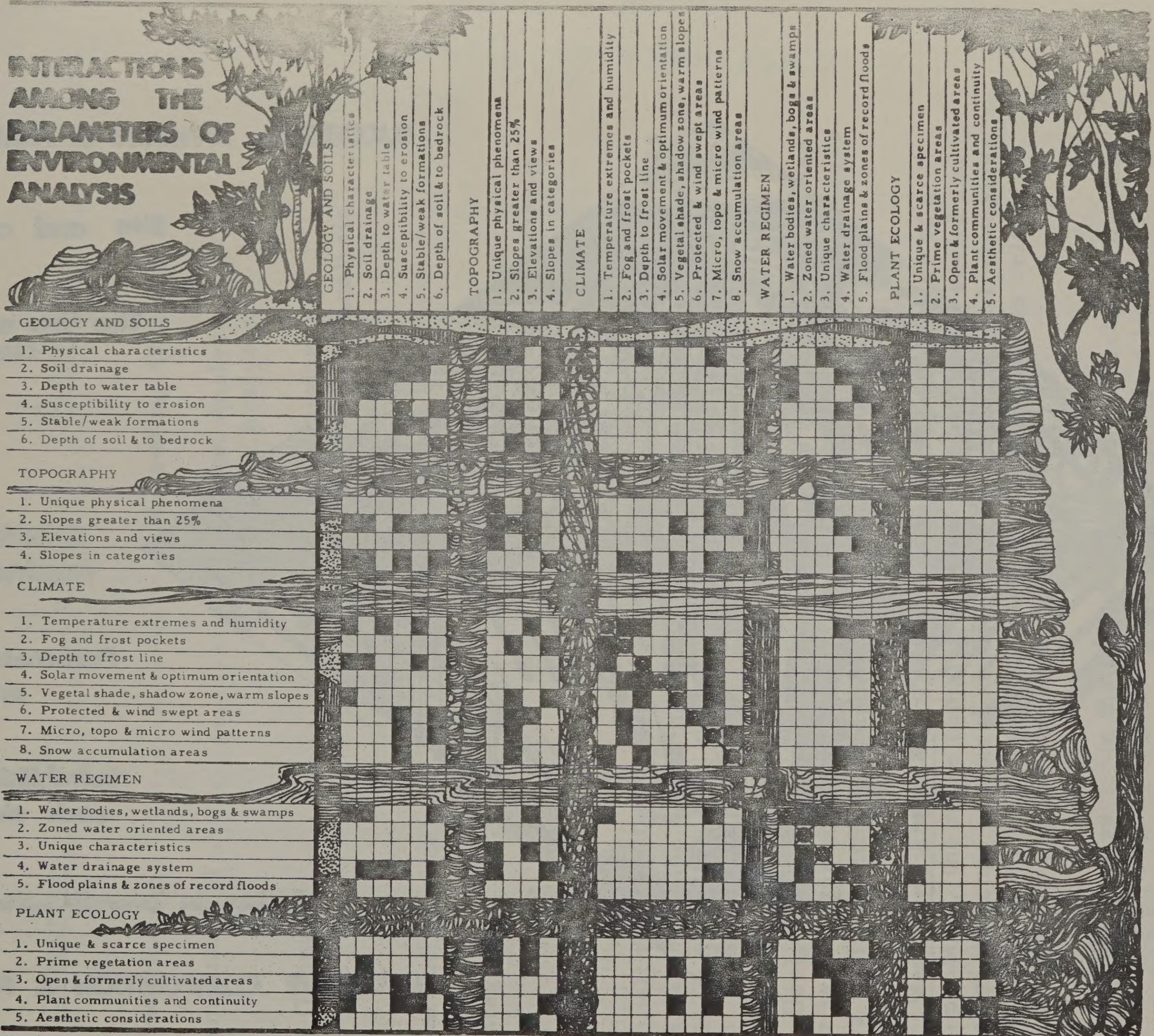
5. Plant And Wildlife Ecology:
   Parameters as: Unique specimen, plant communities, aesthetic considerations... etc.

In evaluating each element through its parameters as formal categories of analysis, it is important to take the interrelationships among parameters into consideration. The matrix showing the interactions among the parameters follows on page **212** . The diagram on page **213** explains the four steps in the process of environmental analysis.

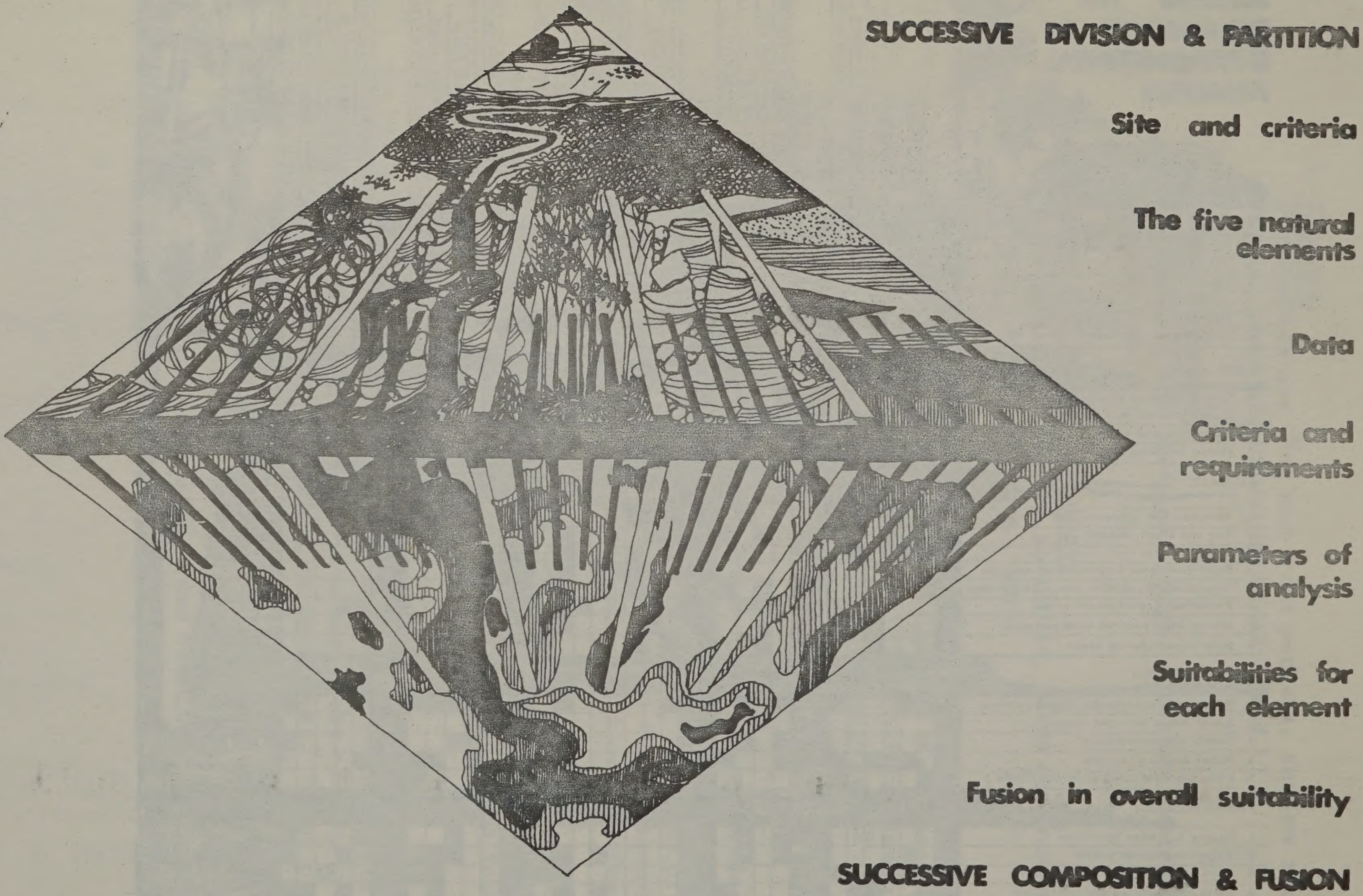
The process of analyzing the human milieu included the process of establishing goals and objectives, of establishing criteria and requirements, and that of programming. The final product in analyzing the human milieu was a topological diagram composed of smaller topological diagrams integrating the human element in design.

The process of analyzing the natural milieu including the process of site data collection was that of environmental analysis. The final product in analyzing the natural milieu was a total suitability analysis.

These processes do not quite fulfill the term "design," as to include the entire question of demand and the resolution of demand relative to supply, including the capacity of the society or institution and/or the government to realize its objectives. Other processes are necessary, together with the ones discussed earlier. Each one of the processes is mainly related to one category of input along the multi-disciplinary lines of the "Technical Awareness Center" structure, with second and third order relationships to other categories of input. The first order relationships are as follows:


INTERACTIONS AMONG THE PARAMETERS OF ENVIRONMENTAL ANALYSIS
GEOLOGY AND SOILS
1. Physical characteristics
2. Soil drainage
3. Depth to water table
4. Susceptibility to erosion
5. Stable/weak formations
6. Depth of soil & to bedrock
TOPOGRAPHY
1. Unique physical phenomena
2. Slopes greater than 25%
3. Elevations and views
4. Slopes in categories
CLIMATE
1. Temperature extremes and humidity
2. Fog and frost pockets
3. Depth to frost line
4. Solar movement & optimum orientation
5. Vegetal shade, shadow zone, warm slopes
6. Protected & wind swept areas
7. Micro, topo & micro wind patterns
8. Snow accumulation areas
WATER REGIMEN
1. Water bodies, wetlands, bogs & swamps
2. Zoned water oriented areas
3. Unique characteristics
4. Water drainage system
5. Flood plains & zones of record floods
PLANT ECOLOGY
1. Unique & scarce specimen
2. Prime vegetation areas
3. Open & formerly cultivated areas
4. Plant communities and continuity
5. Aesthetic considerations

Printed by permission from: "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 97.


SUCCESSIVE DIVISION & PARTITION
Site and criteria
The five natural elements
Data
Criteria and requirements
Parameters of analysis
Suitabilities for each element
Fusion in overall suitability
SUCCESSIVE COMPOSITION & FUSION

Printed by permission from "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 39.

Categories	Processes
Behavioral	Measuring Attitudes
Implementational	Market Analysis Supply Analysis
Form Giving	Programming Environmental Analysis Synthesis
Natural And Physical	Site Data
All Categories	Goals And Objectives Criteria And Requirements

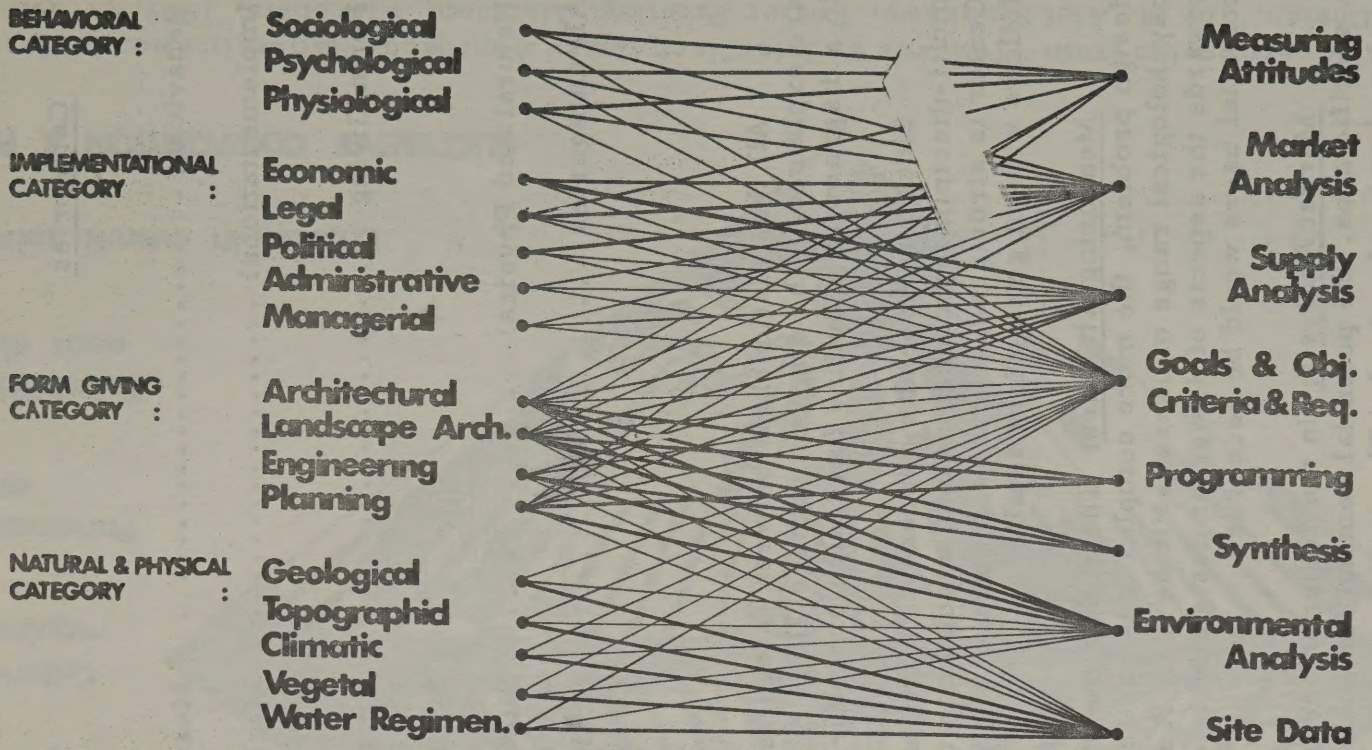
All the relationships between categories and between processes are explained in the diagram on page **215**. Sequential order is explained in a diagrammatic outline for design procedures on page **216**.

Since this Appendix represents a framework for the multi-disciplinary concept; along which lines the Technical Awareness Center is structured; a brief summary of the added terms of processes follows without getting into details.

Measuring Attitudes: The higher the hierarchial order of a design problem, the more complex it is, and the wider the social and psychological range of users' attitudes is. A survey of such attitudes towards the aspects of design or design decision-making as related to potential users would be necessary.

Market Analysis: In the design process of a specific project in a specific area, the potential demand for such a project has be be analyzed and understood. The market analysis of an area involves both the economic forces working in that area and the attitudes of the potential users. The findings of the market analysis defines the limits of the project both physically (sizewise) and economically (expensewise).

THE MULTI-DISCIPLINE TEAM AND THE PROCESSES IN THE "EXPLORATORY AND PRELIMINARY" PHASES OF DESIGN



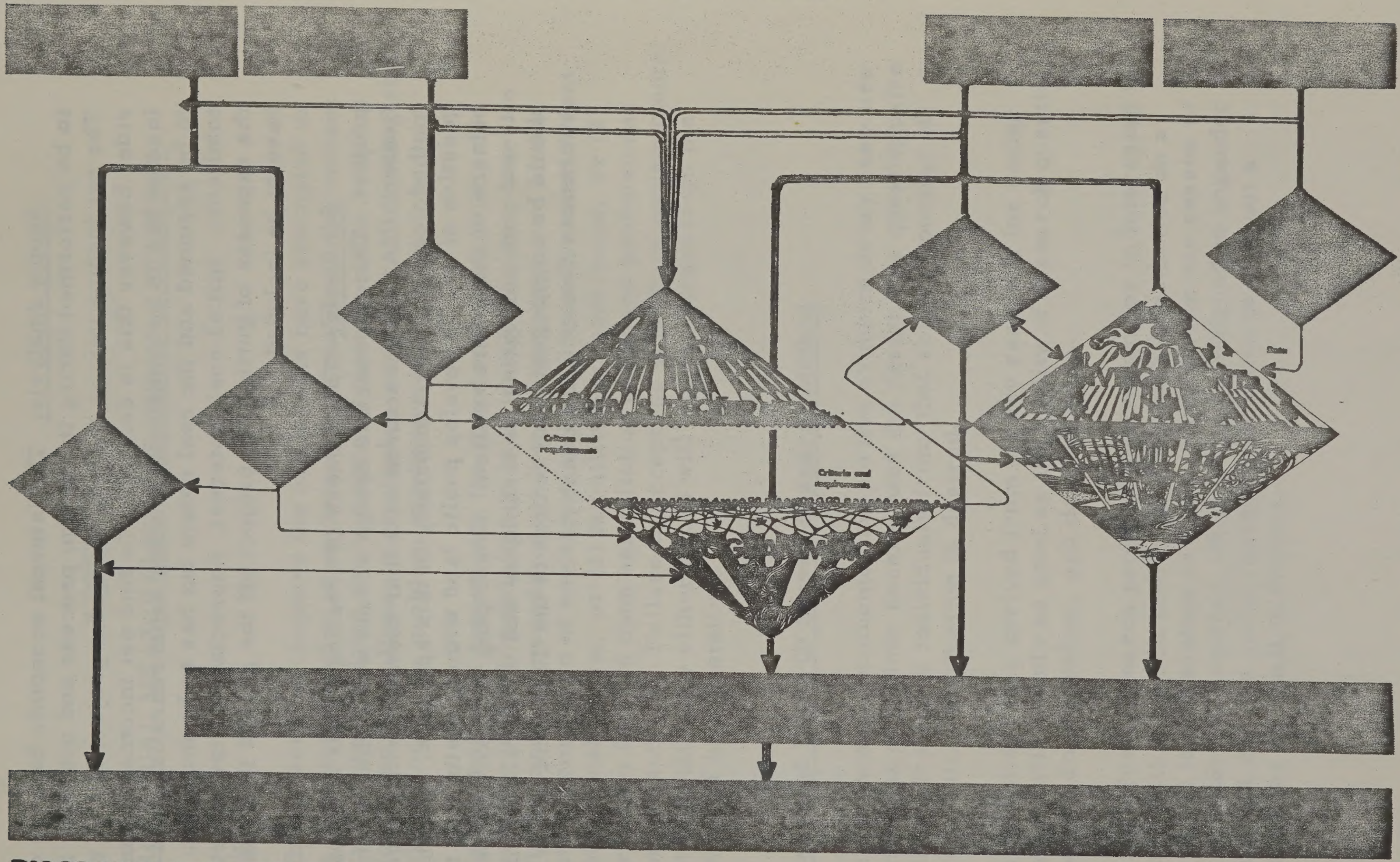
Notation :

Third second, and first order relationships.

Note :
The processes (on the right hand side) are not arranged in sequentional order.

Printed by permission from: "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 84.

AN INTER-DISCIPLINARY APPROACH TO THE DESIGN PROCESS :



DIAGRAMMATIC SEQUENTIAL OUTLINE OF PROCEDURES

Printed by permission from: "Towards an Interdisciplinary Approach, Rationalization in Environmental Design," by M. Atef Sharkawy, Foster Printing, Madison, Wisconsin, 1969, p. 85.

Supply Analysis: The internal economic balance of a project has to be performed during the design process and not after it is completed. The net income versus the total cost of a project has to be on the profit side, however this is defined. To find net income, potential gross income has to be computed; running expenses--fixed and variable--have to be assumed and the real estate tax has to be included. To find the total cost, initial cost, interest, depreciation, tax offset as well as the expenses of getting the project off the ground to a running start, have to be included.

Synthesis: The process of creating forms and spaces for the project. This approach to design around which the "Technical Awareness Center" (TAC) is structured with four teams working together along the methodology summarized briefly in this appendix, can answer the question of how to develop public land without disturbing the critical balance of the natural milieu. Developing such an approach, applying it, and communicating its techniques and technicalities to the public should be an integrated ingredient of the TAC, and of the Environmental Awareness Center consequently.

APPENDIX C.

PERCEPTUAL MEASUREMENT OF HUMAN ATTITUDES

Introduction

In the preceding chapters the consultants have attempted to articulate the interpretation of environmental quality in the context of this study, acknowledging the variance of interpretation relative to study focus and disciplinary (sociologist, ecologist, climatologists, etc.) participation in the problem solving process.

This appendix will investigate the value and applicability of survey research method in relation to individual value responses to various visual landscape conditions. It must be recognized at the outset that determination of environmental quality can be as different as (1) professional dogma, or (2) lay attitudinal constructs, or (3) an interpretation founded upon assimilation of lay and professional insights on the subject. Failure to accept the validity of environmental quality interpretation by either group will surely detract from the completeness of interpretation.

The Process And Value Of Survey Research Method

The absence of documented supportive evidence of lay response to environmental conditions necessitates the design of a questionnaire and its administration to individuals from that selected portion of society from which information is desired.

The potential value derived from survey research (or social measurement) will be only as good as the quality of research questions, questionnaire/administration, and data analysis.

In any survey research project, the researcher is interested in gaining information about a population for which information on a specific subject is nonexistent or is unacceptable for one reason or another. In selected instances, the survey is designed to engender information that enables an increased information base about a population, great or small in number.

Regarding the subject of environmental quality, for example, attitude survey can be a very good way of learning more about those visible elements that residents of a particular area regard highly on a value scale.

The type and quality of information acquired through survey research will result from the structuring and organization of the research design. The process, therefore, is a most important aspect of an attitude survey.

The recognized order of research is outlined below:

1. Determine the information desired.
2. Determine the population from which that information is desired.
3. Prepare a questionnaire designed to gain the desired information.
4. Conduct a questionnaire pre-test.
5. Administer the questionnaire.
6. Evaluate the returns.
7. Specify additional research on the topic researched.

Rationale For A Structured Technique Of Quantitative And Qualitative Determination Of Visual Landscape Quality

Attitude survey has many values and can be applied to a variety of conditions. In the context of determination of environmental quality, the research method should concentrate upon the quantitative and qualitative components related to the question of what constitutes environmental quality.

A factor of environmental quality based upon the consideration of quantitative criteria can be considered in several different ways. Initially, the quantitative criteria of quality relates to the physical area comprised of those components preferred by individual viewers. For example, 40 trees may have scenic (visual) value significantly greater than a single tree.

On the other hand, the qualitative criteria can operate independently from quantitative consideration. The qualitative factor of environmental quality relates to the designation of environmental quality on the basis of quality regardless of volume.

For example, a waterfall, by virtue of uniqueness, is a scenic resource of very significant quality regardless of the land area comprised of that particular landscape resource.

The mutual function of quantitative and qualitative bases would describe environmental quality as an expression of substantial physical area comprised of identified qualitative components.

For example, in recognizing the uniqueness of a given structure such as a log cabin--a cluster of six of these structures represents greater environmental quality than a single log cabin. This does not discount the realization that a single structure constitutes significant value in an area replete of certain quality features such as a log cabin.

Consideration of the quantitative and qualitative criteria of environmental quality must be scrutinized very closely today in respect to our increasing population and the demands of people to derive personal benefit from our nations' resources from the standpoint of the area or quality requirements necessary to satisfy personal requirements or desire.

The interpretation of environmental quality may differ by geographical region as a result of diverse factors including (1) the conditioning of a population to value available resources highly, (2) the regional landscape personality, (3) quantitative or qualitative factors of unique natural and cultural components.

In a nation wherein the population is generative and resources are not, we must be committed to either the preservation of existing resources, or to the inevitable necessity to readjust our value system in respect to diminishing quantitative and qualitative resource quality. The value of 40 acres of prairie today may be supplanted by the equivalent value of 5 acres tomorrow if those 40 acres are not immediately preserved.

Identify Types Of Landscape Components (Natural And Cultural) That Satisfy The Needs Of Many Types Of Individuals

Any investigation into the use of land for public benefit necessitates an identification of the existing and potential adequacy of the landscape to satisfy the needs of the population to be served.

This necessitates an initial understanding of current and potential future usership related to a variety of considerations listed below:

1. What age groups are using existing public land now, and what age groups will be using public land facilities in the future?

2. What income ranges are represented in the current and future visitors to public lands?

3. What are the inferences of various age groups to the active and passive land use requirements from the standpoint of quantity and quality and personal satisfaction derived from available resources?

4. How many visitors can an area accommodate before the quality of the landscape or the enjoyment of the landscape by man is destroyed?

To answer the question of what constitutes environmental quality to the user population, more information must be compiled relative to the range of landscape factors required to satisfy the needs of many individuals--the visitors to public lands. As mentioned earlier, lay interpretation of environmental quality is very likely to be based upon those elements in the landscape that satisfy an individual's needs. A listing of landscape elements satisfying to the layman will very likely include two primary options for enjoyment, including:

1. Landscape conditions that evoke visual pleasure, such as a tree covered hillside, a waterfall, a rock outcropping, etc.

2. Landscape conditions that provide a base for enjoyable forms of physical interaction with the landscape, such as fishing, hunting, hiking, etc.

Acceptance of these two primary criteria for lay environmental quality must be accompanied by a survey research effort designed to identify those specific conditions necessary to satisfy visual pleasure and physical interaction. This information can be obtained by application of a technique to be discussed later.

Lay Standards Of Environmental Quality--Environmental Components Required To Satisfy Human Desires

A detailed investigation of landscape conditions reveals diverse characteristics within a geographical area. For example, in 1961 Philip H. Lewis, Jr., in his work associated with the State of Wisconsin Resource Inventory, defined 62 distinct landscape characteristics in statewide context.

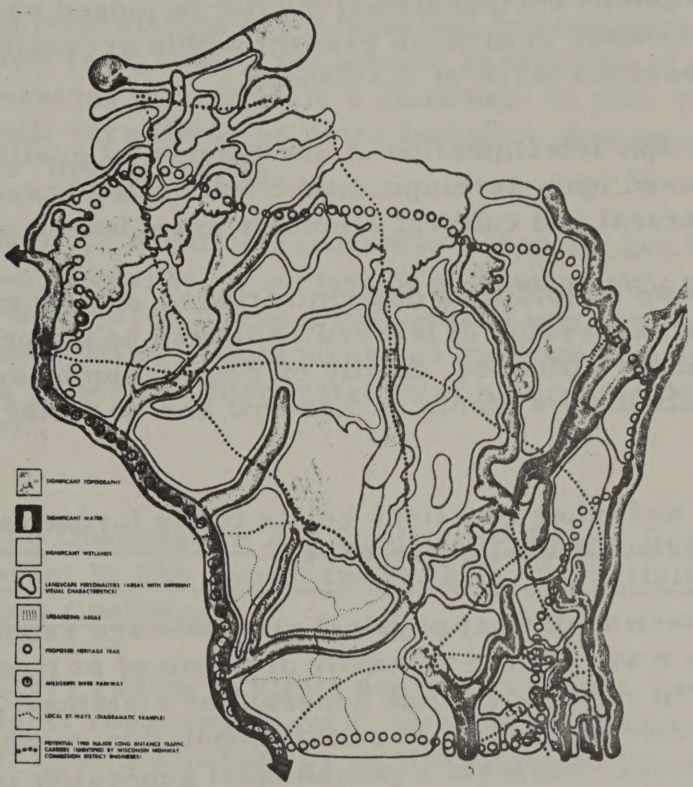

SIGNIFICANT TOPOGRAPHY
SIGNIFICANT WATER
SIGNIFICANT WETLANDS
LANDSCAPE PERSONALITIES (AREAS WITH DIFFERENT VISUAL CHARACTERISTICS)
URBANIZING AREAS
PROPOSED HERITAGE TRAIL
MISSISSIPPI RIVER PARKWAY
LOCAL BY-WAYS (DIAGRAMATIC EXAMPLE)
POTENTIAL 1980 MAJOR LONG DISTANCE TRAFFIC CARRIERS (IDENTIFIED BY WISCONSIN HIGHWAY COMMISSION DISTRICT ENGINEERS)

Fig. C. 1

Even greater variation of landscape characteristics can be identified within each of the 62 areas thereby suggesting the complexity associated in attempting to classify landscape characteristics within a geographical context such as a state or sub-region.

An expanded scope of interest such as the scale involved in the investigation of public lands creates a considerable problem when attempting to isolate particular physical landscape characteristics applicable to a workable scale. From the standpoint of human usership of public lands, however, these diverse national, regional and state characteristics of physical geography provide a range of land uses based upon particular landscape characteristics such as the area and quality of water, whether slopes are suitable for skiing, the availability of navigable rivers, and other similar considerations.

The question of what constitutes environmental quality from the standpoint of the layman raises complexities and a variety of viewpoints. Several primary considerations include:

1. Whether environmental quality is judged on the basis of resource conditions present within accessible distance from the place of residence.

2. Is the determination of environmental quality by individuals based upon developmental conditioning based upon those natural and cultural elements experienced as a child?

3. Is an individual's determination of environmental quality an expression of learned patterned behavior based on family affluence, family or peer group biases, an individual's ethnic background and so forth?

These and other questions relate to the formation of individual and group environmental preferences.

The question of what physical elements are required to satisfy human needs may seem to be easily determined at first thought, particularly in reference to the generalized statement--human needs. The diverse composition of a national population exceeding two hundred million, however, suggests a monumental generality in daring to exact a definition that includes all people.

Investigation into the process of human development reveals five distinct phases including infancy, childhood, adolescence, adulthood and old age. Throughout the process of aging, man changes and adapts to his environment and has changing likes and dislikes about many things, including his environmental preference. As a youngster, an individual may derive pleasure climbing a tree; but as an elderly person a crimson colored tree in the autumn may provide the source of enjoyment. An individual's satisfaction derived from physical landscape resources change as an individual ages.

Patterns of great diversity identified in this report are more likely to offer environmental experience for all ages.

An extremely significant question related to environmental quality returns to the degree of correlation between professional and lay determination of environmental quality within the national, regional, statewide, and county scales of consideration. The professional with his knowledge accrued from an educational and experiencial base can prescribe his own disciplinary interpretation of environmental quality. A complete interpretation of professional interpretation of quality will only result from asking recognized spokesmen of all environmental-related professions to articulate a statement on this question. These statements will very likely be more inclusive than any single professionals' interpretation.

Similarly, in order to accurately articulate lay interpretation of environmental quality, a variety of population cohorts by geographical region must be queried to exact individual response to the question of environmental quality. Subsequent to a random sampling of a region's population, a collective interpretation of environmental quality can be accomplished.

Determine The Quantitative And Qualitative Extent Desired Conditions Must Be Present In The Landscape In Order To Satisfy Human Desires On A High-Low Continuum

The survey research effort designed to learn those landscape conditions highly regarded by man, thereby comprising environmental quality, must be accompanied by an investigation into the qualitative and quantitative requirements valued conditions must have in order to be assigned a high value by an individual. It would be extremely significant and useful to document the following unknowns:

1. On what basis do various age, sex, income and education groups define quality?

2. On what basis do various age, sex, income and education groups assign quality as a product of quantity?

3. In what instances does quality surpass the importance of quantity and vice versa, and if so, which ones?

4. Do certain landscape conditions require more quantity than others to constitute a quality situation and if so, which ones?

5. At what precise quantitative level do various landscape conditions receive a value sufficient to constitute a quality designation?

Following the public response to these questions by the population of various regions in the United States, it would then be possible to understand what criteria regional lay populations consider in the determination of environmental quality. After these regional criteria of quality have been established from an attitude survey, similarities or disimilarities of regions can be established.

Identify Those Components That Detract From The Visual Quality Of The Landscape

In our travels within cities and throughout the countryside the visual quality of the things we see are often diminished by objects that scar the landscape. These offensive elements include junk yards, billboards and utility poles, to mention only a few. In many situations the removal or screening of these visually offensive components will restore visual quality to previously degenerated conditions. The creation of and maintenance of environmental quality on public lands must include the removal of and control against offensive objects that detract from the scenic quality of a landscape.

In addition to these structural blights created by man, thoughtless human activity too frequently diminishes the visual quality and health of a landscape. Frequent offenses in this category include bulldozed hillsides, abandones extraction sites, and overgrazed hillsides, to mention only a few of such offenses. A rank ordering of these and other offenses could be accomplished in an attitude survey of the visitor population utilizing existing public lands. These offenses must not be permitted in lands reserved for public use or anywhere else for that matter.

Recognizing the possibility that these blight conditions could occur outside public lands, and yet be visible from within public lands, the use of visual screens may be appropriate in minimizing or eliminating visual access of offensive conditions from within public holdings.

From the standpoint of the management of public lands to preserve or restore environmental quality, a rank ordering of objectionable conditions on a high-low continuum could be useful to park management personnel in appropriating expenditures for screening in order to use available funds to maximum gain. In this regard, management should know which visual conditions people will or will not tolerate.

The Environmental Analyzer Technique

The discussion to this point has concentrated on the needs for and values derived from conducting attitude studies to learn more about people's environmental preferences. One technique designed to accomplish the objectives discussed herein is included as a technique potentially applicable to documenting lay criteria of environmental quality.

As the perceptive individual views his world, he may discover that the objects viewed are very much the same from place to place--a tree here, a building there, a paved street, and so forth. Closer observation, however, reveals that the volume and relationships of these objects can be vastly different. The author, recognizing these diversities, was prompted to learn more about the relationship of these objects as they affect the quality of the environment.

In his book Townscape, Gordon Cullen states:

> "In fact, there is an art of relationship just as there is an art of architecture. Its purpose is to take all the elements that go to create the environment: buildings, trees, nature, water, traffic, advertisements and so on, and to weave them together in such a way that drama is released."(1)

---

(1) Gordon Cullen, Townscape (New York: Reinhold Publishing Corp., 1961), pg. 10.

The preceeding comments aptly describe the reason for and intent of the writing of the thesis. The thesis concentrates upon the development of a tool called the Environmental Analyzer, to aid the form giver in learning more about these relationships of visual elements that result in man's favorable or unfavorable response to the world he sees. The objectives of the thesis were two-fold. The first objective is to further the form giver's knowledge of factors that can aid him in gaining a better understanding of the quantitative mix of components that comprise the physical landscape. The second, and no less important objective, is the development of a technique that incorporates lay value response to existing visual conditions.

Related to the question of professional or lay perception of the physical world around us, Kevin Lynch, in The Image Of The City asserts:

> "To extend and deepen our perception of the environment would be to continue a long geological and cultural development which has gone from the contact senses to the distant senses and from the distant senses to symbolic communications. Our thesis is that we are now able to develop our images of the environment by operation on the external physical shape as well as the internal learning process. Indeed, the complexity of our environment compels us to do so."(2)

The average man on the street may feel that it is unnecessary to discuss the manner in which he perceives his environment because he believes, on the surface at least, that he is quite familiar with the world around him. M. D. Vernon states in the Psychology of Perception:

> "He is so familiar with his 'real world' and the objects it contains that it would not occur to him that there is any need to speculate as to how it is that the world appears as it does. The objects out 'there' in space; they appear in their familiar aspects and therefore he knows what they are, what they do, and what he can do with them."

---

(2) Kevin Lynch, The Image Of The City (Cambridge: The M. I. T. Press, 1959) p. 12.

> "Knowledge of the identity of objects and features in the environment is obviously valuable to us. Not only does the apparent stability and permanence of most of them create a feeling of security; it also enables us to react to them rapidly and appropriately."(3)

According to Vernon, the variations and interruptions of the perceptive process are:

> "... caused partly by the great complexity of the perceived field of view as constituted by our normal surroundings; and partly by limitations of the perceptual capacity of the observer. He can view only a small part of his surroundings at any one moment; and even when he scans them deliberately, there is much that he tends to overlook or to perceive incompletely or inaccurately. Undoubtedly, during the course of his life he learns to perceive more, and more accurately, especially when he has an interest in doing so, or when he has received special training. But the effects of knowledge and experience are in themselves liable to produce selective perception and the funneling of attention to objects and events about which special knowledge and experience have been acquired. The consequence is that no two observers may perceive a given scene in exactly the same manner, that they may disagree considerably as to its nature and contents.(4)

The role of the form giver in the education of lay citizens becomes one of simplifying his analysis of the environment and transferring these findings in a manner that will be understood.

---

(3) M.D. Vernon, The Psychology of Perception (Baltimore Penguin Book, 1962), p. 437.

(4) Ibid., p. 348.

Part of his task, therefore, is to communicate his ideas in an easily understood frame of reference.

A desire to better understand some of the reasons underlying the inherent characteristics of the environment, as well as the recognition that the professional must know more about lay preferences of visual conditions led to the development of a graphic measuring technique to aid in the analysis of the various visual elements comprising the observed scene.

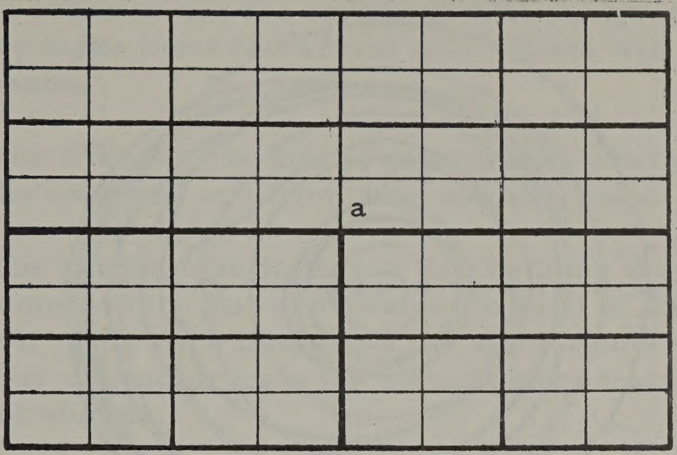
The distinct advantage of the environmental analyzer, lies in the possibility it presents for the calculation of the percentages of the total visual field that the various significant components of the environment comprise. By using percentages, the designer is able to determine what differences exist in one view as contrasted to a different view.

The use of this technique enables the user to analyze the environment on a systematic basis, and therefore develop a better understanding of some of the factors which contribute to visually pleasing or displeasing visual stimuli. The environmental analyzer also permits the user to become aware of environmental inconsistencies that exist in various views.

In the process of attempting to convey visual differences to laymen, or vice versa, the form giver often resorts to the use of descriptive comments such as "greater than," less than," or "equal to." The use of such terms results in ambiguities because people's understanding of "greater or less than" differs considerably. Application of the analyzer enables its user to overcome reliance upon these imprecise words as environmental characteristics can be conveyed in a quantitative manner.

The environmental analyzer enables the form giver to say, for example, that view A contains 40 per cent trees and view B contains 15 per cent trees. This results in more precise communication than merely stating that view A has more trees than view B.

The Measurement Grid (an exact duplicate of the image area of a 35 m.m. slide) which comprises the most important aspect of the environmental analyzer technique consists of 64 equal sized rectangles. The total area of the grid represents 100 per cent of the human field of vision. Each of the rectangles represent approximately 1.56 per cent of the visual field.



a - fixation point

Fig. C. 2

When an individual looks intently at one fixed point, that point upon which he focuses is called the fixation point. Opthalmologists regard the fixation point as the center of the visual field. From a physiological standpoint, the miniscule spot on the retina of the eye, through which an individual looks at the fixation point is called the fixing point.

The horizontal extension of this point divides the visual field into an area above and below the fixation point. Similarily, a vertical line through the horizontal fixation point separates the visual field into a larger temporal and small nasal half and is called the decussation line. Everything on one side of the decussation line is recorded on one side of the brain, and everything on the other side is registered on the other side of the brain.

The field of vision consists of angles 50-55 degrees upward, 70-80 degrees downward, 60 degrees nasalward and 94 degrees templeward.

Vertically the brow obstructs upward vision. The cheek limits downward vision. Horizontal vision inwardly is obstructed by the nose, and vision outwardly is relatively unimpaired. The resultant visual field, therefore, is essentially oval.

Illustration[5]

The human visual field

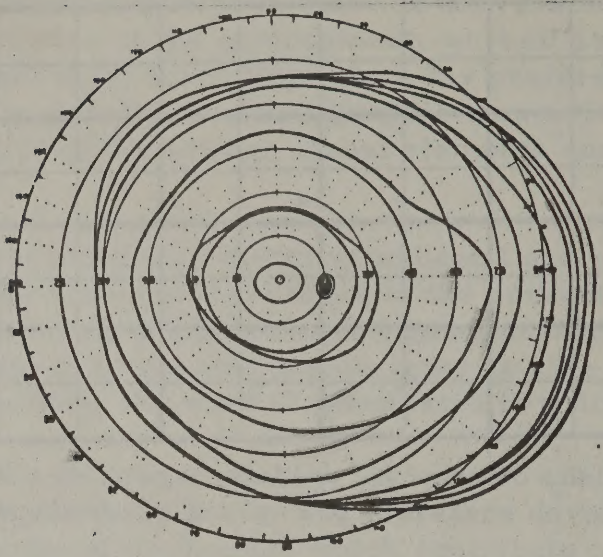


Fig. C. 3

The superimpositions of a rectangle representing the dimensions of a 35 millimeter camera's image area over the diagram of the binocular visual field illustrates that although some difference exists, the rectangle does not comprise a too significant departure from the human visual fields.

The human field of vision combined with the camera image area.

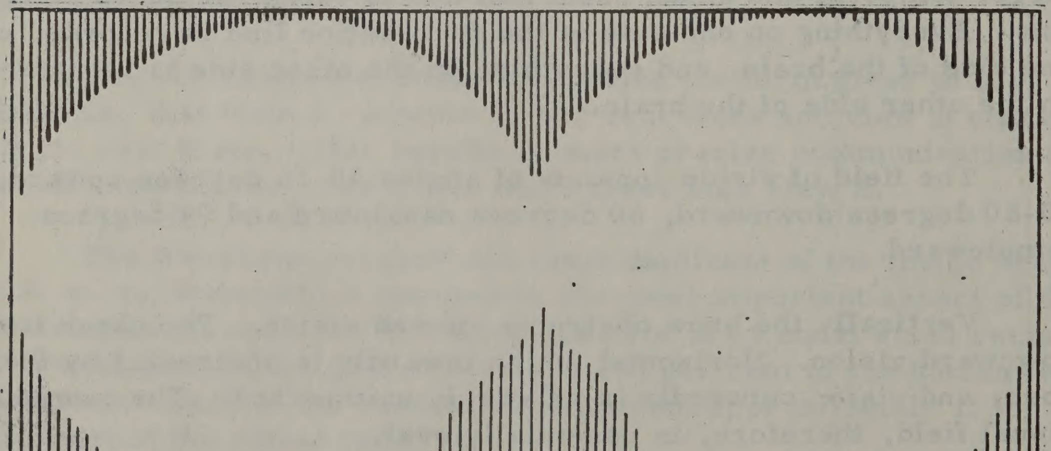


Fig. C. 4

---

[5] Brodie Hughes, The Visual Fields, (Oxford: Blackwell Scientific Publications, 1954), p. 19

In order to use the environmental analyzer, several preliminary tasks must be carried out. These will be discussed in sequence.

The first task is that of determining what precise views are to be analyzed and from what vantage point.

The second task is that of determining the significant visual components that are present in each of the views to be analyzed. It is very likely that the components to be observed will differ depending upon the visual components present in different studies.

Natural components in the context of this thesis include those visual elements in the urban environment that nature provides. The natural components referred to in this study are, for the most part, unaltered by man. Man-made components, on the other hand are those visual elements that man has fabricated.

Natural Components

Controlled Open Spaces: Controlled open spaces consist of grassy areas, maintained by man that usually enhance the area surrounding buildings of private as well as public uses.

Natural Open Spaces: Natural open spaces consist of verduous areas unaltered by man. They include meadowland, agricultural lands, open space areas containing natural plant life, etc.

Sky: The sky component consists of the expanse over the earth that takes on appearances ranging from a clear blue area to a space comprised of varying degrees of cloudiness.

Trees and Shrubbery: This component includes all species of woody perennials comprised of either a single trunk terminated by branches of variegated size or several stems instead of a single trunk.

Water: The water component is a general term used to connote inland bodies of water including lakes, ponds, rivers and creeks.

Cultural Components

Buildings: The Buildings component includes any structure such as a house, school, or dormitory building.

Non-Surface Components: This is an open category created to include those elements of the environment that differ between land use areas. The components contained in this category are noted in the spaces provided in the Master Data Sheet whenever components appropriate to this category are observed. These components include utility poles, signs (commercial or highway), street lights, and other such things.

Pedestrian-Paved Areas: This component consists of all hard surfaces allotted for the purpose of pedestrian circulation. Pedestrian-paved components include elements such as sidewalks, paved hiking paths, and pedestrian malls.

Vehicular-Paved Areas: The vehicular-paved consists of all hard surfaces including cement, asphalt, macadam, etc., for the purpose of vehicular circulation. These include streets, loading areas, parking lots and similar facilities.

The third task in the technique is that of projecting each 35 m.m. slide onto the measurement grid and estimating the percentage of each significant component in each view. This is accomplished by observing the amount of coverage of the component within each of the rectangles where that particular component appears. The master data sheet on the following page illustrates the quantitative distribution of significant components of various streets in an urban area.

MASTER DATA SHEET: RESIDENTIAL AREA--WEST-CENTRAL SIDE

	Natural Components					Man-Made Components							
							Non-Surface Components						
	Controlled Open Spaces	Natural Open Spaces	Sky	Trees and Shrubbery	Water	Buildings	Utility Poles	Signs	Pedestrian-Paved	Vehicular-Paved	Dominant	Sub-Dominant	Sub-Sub-Dominant
Street Name	A	B	C	D	E	1	2	3	5	6			
e: Peck to Main	11.0		6.5	27.0		9.0	1.5		0.5	44.5	6	D	A
eth: Melrose to Walworth	8.0		24.0	6.5		6.0	0.5		1.0	45.0	6	C	A
e: Elizabeth to Pleasant	7.0		31.5	5.5		5.0				51.0	6	C	A
nd: Prince to Whiton	10.5		7.0	43.0		2.0				37.5	D	6	A
: Prince to Whiton	13.0		3.5	46.0		4.0	1.0		2.0	30.5	D	6	A
nt: Walworth to Melrose	12.5		41.5	1.0		9.5				35.0	C	6	A
: Main to Highland	7.5		14.0	28.0		6.5				44.0	6	D	A
e: High to Main	11.0		43.5			8.0	1.5		1.0	35.0	D	6	A
: Highland to Main	12.0		6.5	34.0		6.0	3.0		1.0	37.5	6	D	A
: Highland to Walworth	13.0		3.0	34.5		10.5	1.5		1.5	36.5	6	D	A
e: Peck to Janesville	8.5		5.0	40.0		11.5	1.5			34.5	D	6	1
nd: Elizabeth to Prince	10.5		9.5	31.0		6.5				42.5	6	D	A
: Summit to Franklin	11.5		1.5	48.0		5.5	2.5		0.5	30.5	D	6	A
Franklin to Whitewater	6.0		3.5	32.0		4.0	2.5			51.5	6	D	A
: Franklin to Third	11.5		1.5	48.0		5.5	2.5		0.5	30.5	D	6	A
: Peck to Main	10.5		1.0	40.5		5.0			0.5	42.5	6	D	A
vater: Janesville to Church	10.0		5.0	38.5		9.5			0.5	36.5	D	6	A
Per Cent	10.16		9.87	33.26		5.88	1.00		0.53	40.01			
ominant, Sub-Dominant, and ub-Sub-Dominant Characteristics f the area											6	D	A

Fig. C. 5

Lay Participation in the Environmental Analyzer Technique

The desire to understand lay values as they relate to environmental quality eventually involves the exposure of a sample population from a specified geographical area to 35 millimeter photographs of pertinent visual conditions.

Value response by a specified population can be achieved by drafting an attitude response similar to the response form presented on the following page.

ATTITUDE RESPONSE FORM

THE UNIVERSITY OF WISCONSIN DEPARTMENT OF LANDSCAPE ARCHITECTURE AND

THE ENVIRONMENTAL AWARENESS CENTER

WAUPACA RIVER VISUAL ANALYSIS QUESTIONNAIRE

This survey of your responses to existing visual conditions of the Waupaca River is being conducted in order to learn more about how individuals evaluate the quality of a variety of visual conditions.

It is our belief that successful environmental design must be the manifestation of human desire (revealed through public participation) and the talent of the professional physical planner.

This survey is not an exam but rather a value study to offer you an opportunity to reveal your response to a variety of existing visual conditions.

The University of Wisconsin, Department of Landscape Architecture is most appreciative for your participation in this analysis.

DIRECTIONS:

Rating Scale:

1=very desireable view
2=undesirable view
3=neutral (no opinion)
4=desirable view
5=very desirable view

Comments:

In this column you are asked to write a brief description of why you rated the view as you did.

Slide No.	Circle the number that best describes your feeling toward each view.	What feature did you like or dislike about the view?
1	1 2 3 4 5	:
2	1 2 3 4 5	:

The attitude response form is comprised of two response columns.

In the first column, the respondent is asked to rank the view on a system from one (1) to five (5). The graduated numbers 1, 2, 3, 4 and 5 relate to a value scale. One is equivalent to very undesirable; five is equivalent to very desirable; whereas three is equivalent to a no-judgement response. Thus the respondent has a good span of value response alternatives, encircling one value number for each separate slide.

The second column provides space for the respondent to briefly state why he rated the view as he did in column one. By providing the space for the respondent's written judgement, rather than providing several choices, the individual is free from the built-in bias associated with closed choices. Thus the individual in encouraged to respond freely as his or her aesthetic values prescribe.

After the sample population has completed filling in the attitude response form, the researcher may then proceed with the analysis of participant responses.

The analysis is comprised of three basic stages. Stage one concentrates on determination of the mean; the average response to each view as recorded on the attitude response form. Stage two involves reviewing the verbal responses to each view and determining why the population responded as they did to each view. Thirdly, the researcher must project each view onto the measurement grid, as described earlier, estimating the quantity of each significant component present in each view.

The ratio of significant visual components can then be related to the value and rationale response representing the average.

In an era of increasing numbers of people, we must not lose sight of the dignity and importance of individuals and the need to maintain a healthy environment that will satisfy man's recognized need for diversity. This task can be more adequately satisfied by establishing communication between the environmental planner and the public at large and therein lies the importance of attitude survey.

APPENDIX D

HIGHWAY CORRIDOR AND ALIGNMENT LOCATION SYSTEM

Context

In October, 1969, the University Board of Regents accepted a research grant from the State of Wisconsin, Department of Transportation, in the name of the Environmental Awareness Center. The purpose of this grant was to devise a corridor and alignment location system for Interstate 57 between Milwaukee and Green Bay--a rectangle approximately 120 miles long and some 60 miles wide.

Process Methodology

The basic intent of the corridor selection study was to develop a system by which social, economic, aesthetic, and ecological factors could simultaneously be used to determine an Interstate location. Highway location decisions have historically been based on the evaluation of a limited factor bank. From an analysis of highway determinant factors, we originated a list of 146 variables or factors which would influence, should influence, or would be influenced by the location of a major highway system such as an Interstate. An evaluation of current methodology showed that there were limited means suitable to handle this number of variables. Since typical planning-design methods are restricted when a multiplicity of variables are to be evaluated simultaneously, it was evident that mechanical and other relevant technological methods were necessary.

The decision was made to evaluate computer technology and to research present computerized land use evaluation programs. Some work had previously been done within the Department of Landscape Architecture by Professor Bernard J. Niemann, Jr., in Dane County, Wisconsin. Additionally, the Department staff was aware of the work being done by the Laboratory for Computer Graphics at Harvard University by Carl Steinitz, through the joint appointment of Prof. Lewis at Harvard.

Because of the time constraint imposed by the State contract, it was necessary to utilize an existing computer program and place the emphasis on evaluation of existing data rather than to develop a program. To utilize an existing computer evaluation and graphic display program, we consulted with Steinitz, Rogers and Associates, Cambridge, Massachusetts, to purchase the GRID program and provide advisory assistance on its use. The use of the consultants provided the Awareness Center staff the opportunity of concentrating upon identifying critical data, data collection, evaluation and manipulation to determine various locations of an Interstate highway based upon varying natural and cultural values.

Data Selection, Collection and Storage

The data selection and collection method was based upon the evaluation of available data related to highway location. Enclosure 1 provides a listing of the data set. The three basic groupings of the data set are (a) Land Use Characteristics, (b) Environmental Characteristics, and (c) Constraints. They form the basis of our highway location variables.

Data was extracted from the different sources, of which the USGS maps and aerial photography were the primary sources. The basic data storage unit was a one kilometer square grid based on the Universal Transverse MeCator (UTM) mapping system. The UTM system is the only mapping system recognized and used world-wide; therefore, allowing the data bank to become compatible with any other area based on this system.

The storage capacity of the GRID program allows for storage of (many) variables of which 142 have been used in this study. One constraint in the data inventory phase has been the absence of uniform, usable data. Optimately, the Center prefers to use specially developed inventory techniques, including forms of remote sensing now being explored with NASA grants.

ENVIRONMENTAL AWARENESS CENTER

Milwaukee-Green Bay Interstate Variables

USE CHARACTERISTICS

WATER - Predominate Type

Predominate Type

0 = None
1 = Wetland
2 = Intermittent Stream
3 = Stream
4 = Minor River
5 = Major River
6 = Lake or Pond Less than 50 Acres
7 = Lake
9 = Lake Michigan

WATER - Intermittent Stream

% of Cell

2 -- 00 = None
to
99 = 100%

WATER - Stream

% of Cell

3 -- 00 = None
to
99 = 100%

WATER - Minor River

% of Cell

4 -- 00 = None
to
99 = 100%

WATER - Major River

% of Cell

5 -- 00 = None
to
99 = 100%

WATER - Pond or Lake Less than 50 Acres

% of Cell

6 -- 00 = None
to
99 = 100%

WATER - Lake

% of Cell

7 -- 00 = None
to
99 = 100%

WATER - Lake Michigan

% of Cell

9 -- 00 = None
to
99 = 100%

ECOLOGICAL ASSOCIATIONS - Predominate Type

Associations

0 = None
1 = Barren Land
3 = Upland Forest
6 = Lowland Forest
9 = Open Swamp

ECOLOGICAL ASSOCIATIONS - Barren Land

% of Cell

1 -- 00 = None
to
99 = 100%

ECOLOGICAL ASSOCIATIONS - Upland Forest

% of Cell

3 -- 00 = None
to
99 = 100%

ECOLOGICAL ASSOCIATIONS - Lowland Forest

% of Cell

6 -- 00 = None
to
99 = 100%

ECOLOGICAL ASSOCIATIONS - Open Swamp

% of Cell

9 -- 00 = None
to
99 = 100%

EXISTING LAND USE - Residential

Predominant Type

0 = None
2 = Rural
4 = Vacation
6 = Suburban
8 = Urban

EXISTING LAND USE - Residential/Rural

% of Cell

2 -- 00 = None
to
99 = 100%

EXISTING LAND USE - Residential/Vacation

% of Cell

4 -- 00 = None
to
99 = 100%

EXISTING LAND USE - Residential/Suburban

% of Cell

6 -- 00 = None
to
99 = 100%

EXISTING LAND USE - Residential/Urban

% of Cell

8 -- 00 = None
to
99 = 100%

EXISTING LAND USE - Commercial

% of Cell

00 = None
to
99 = 100%

EXISTING LAND USE - Industrial

% of Cell

00 = None
to
99 = 100%

EXISTING LAND USE - Recreational

% of Cell

00 = None
to
99 = 100%

EXISTING LAND USE - Institutional

% of Cell

00 = None
to
99 = 100%

EXISTING LAND USE - Agricultural

% of Cell

00 = None
to
99 = 100%

EXISTING LAND USE - Roadways: Town Road - Unpaved

Number Per Cell

1 - 00 = None
to
99 = 100

EXISTING LAND USE - Roadways: Town Road - Paved

Number Per Cell

2 - 00 = None
to
- 99 = 100

EXISTING LAND USE - Roadways: County Road
Number Per Cell
3 - 00 = None
to
- 99 = 100

EXISTING LAND USE - Roadways: State Highway

Number Per Cell

4 - 00 = None
to
- 99 = 100

EXISTING LAND USE - Roadways: Federal Highway

Number Per Cell

5 - 00 = None
to
- 99 = 100

EXISTING LAND USE - Limited Access Highway

Number Per Cell

7 - 00 = None
to
- 99 = 100

EXISTING LAND USE - Interchange

Number Per Cell

9 - 00 = None
to
- 99 = 100

EXISTING LAND USE - Transportation Facilities

Type

0 = None
2 = Air
4 = Rail
6 = Bus
8 = Port

EXISTING LAND USE - Transportation Facilities: Air

Type

2 - 0 = None
- 3 = Local Airfield - Turf
- 6 = Minor Airfield - Paved non-FAA
- 9 = Major Airfield - Paved FAA

EXISTING LAND USE - Transportation Facilities: Rail

Type

4 - 0 = None
- 4 = Rail Terminal - Freight
- 8 = Rail Terminal - Passenger

EXISTING LAND USE - Transportation Facilities/Port

Type

8 - 0 = None
- 3 = Port Facilities - Cargo
- 6 = Port Facilities - Passenger
- 9 = Port Facilities - Recreational

PROJECTED LAND USE - Agricultural

% of Cell

00 = None
to
99 = 100%

PROJECTED LAND USE - Residential

% of Cell

00 = None
to
99 = 100%

PROJECTED LAND USE - Institutional

% of Cell

00 = None
to
99 = 100%

PROJECTED LAND USE - Commercial

% of Cell

00 = None
to
99 = 100%

PROJECTED LAND USE - Industrial

% of Cell

00 = None
to
99 = 100%

PROJECTED LAND USE - Recreational

% of Cell

00 = None
to
99 = 100%

ENVIRONMENTAL CHARACTERISTICS

TOPOGRAPHIC ORIENTATION - Degree of Orientation

Degree of Orientation

0 = Flat
2 = Single Direction
5 = Two Directional
7 = Three Directional
9 = Four Directional

TOPOGRAPHIC ORIENTATION - Single Direction

Orientation

2 - 0 = None
- 1 = S
- 2 = SW
- 3 = SE
- 5 = E
- 6 = W
- 7 = NE
- 8 = NW
- 9 = N

TOPOGRAPHIC ORIENTATION - Two Directional

Orientation

5 - 0 = None
- 1 = S and W
- 2 = S and E
- 3 = E and W
- 5 = NE and SW
- 6 = NW and SE
- 7 = N and S
- 8 = N and E
- 9 = N and W

TOPOGRAPHIC ORIENTATION - Three Directional

Orientation

7 - 0 = None
- 1 = E and S and W
- 2 = NE and SE and SW
- 3 = SE and SW and NW
- 4 = N and E and S
- 5 = S and W and N
- 6 = SW and NW and NE
- 7 = NW and NE and SE
- 8 = W and N and E

TOPOGRAPHIC SLOPE - 0-2%

% of Cell

00 = None
to
99 = 100%

TOPOGRAPHIC SLOPE - 3-6%

% of Cell

00 = None
to
99 = 100%

TOPOGRAPHIC SLOPE - 7-12%

% of Cell

00 = None
to
99 = 100%

TOPOGRAPHIC SLOPE - 13-20%

% of Cell

00 = None
to
99 = 100%

TOPOGRAPHIC SLOPE - 21% Plus

% of Cell

00 = None
to
99 = 100%

TOPOGRAPHIC ELEVATION - Highest Elevation in Cell

Feet - Sea Level Datum - To Nearest Foot - Absolute Value - Four Digits

TOPOGRAPHIC ELEVATION - Lowest Elevation in Cell

Feet - Sea Level Datum - To Nearest Foot - Absolute Value - Four Digits

TOPOGRAPHIC ELEVATION - Centroid Elevation

Feet - Sea Level Datum - To Nearest Foot - Absolute Value - Four Digits

SOILS

Stratum

0 = None
3 = Surface
6 = Subsurface
9 = Substratum

SOILS - Surface

Class USCS

3 - 00 = None
- 10 = Gravels - GC
- 20 = Gravels - Silt/Clay - GF
- 30 = Sands, Sandy Gravels - SC
- 40 = Sands, Silt/Clay - SF
- 61 = Inorganic Silts and Very Fine Sands, Clayey Silts - Low Plasticity - ML
- 62 = Inorganic Clays, Sand Clays, Silty Clays - Low Plasticity - CL
- 63 = Organic Silts, Silt Clays - Low Plasticity - OL
- 71 = Inorganic Silts, Elastic Silts - High Plasticity - MH
- 72 = Inorganic Clays - High Plasticity - CH
- 73 = Organic Clays - Organic Silts - High Plasticity - OH
- 80 = Peat - PT
- 90 = Bedrock

SOILS - Surface: GC

% of Cell

3 - 10 - 00 = None
to
99 = 100%

SOILS - Surface: GF

% of Cell

3 - 20 - 00 = None
to
99 = 100%

SOILS - Surface: SC

% of Cell

3 - 30 - 00 = None
to
99 = 100%

SOILS - Surface: SF

% of Cell

3 - 40 - 00 = None
to
99 = 100%

SOILS - Surface: ML

% of Cell

3 - 61 - 00 = None
to
99 = 100%

SOILS - Surface: CL

% of Cell

3 - 62 - 00 = None
to
99 = 100%

SOILS - Surface: OL

% of Cell

3 - 63 - 00 = None
to
99 = 100%

SOILS - Surface: MH

% of Cell

3 - 71 - 00 = None
to
99 = 100%

SOILS - Surface: CH

% of Cell

3 - 72 - 00 = None
to
99 = 100%

SOILS - Surface: OH

% of Cell

3 - 73 - 00 = None
to
99 = 100%

SOILS - Surface: PT

% of Cell

3 - 80 - 00 = None
to
99 = 100%

SOILS - Surface: Bedrock

% of Cell

3 - 90 - 00 = None
to
99 = 100%

SOILS - Subsurface

Class USCS

6 - 00 = None
- 10 = Gravels - GC
- 20 = Gravels - Silt/Clay - GF
- 30 = Sands, Sandy Gravels - SC
- 40 = Sands, Silt/Clay - SF
- 61 = Inorganic Silts and Very Fine Sands, Clayey Silts - Low Plasticity - ML
- 62 = Inorganic Clays, Sand Clays, Silty Clays - Low Plasticity - CL
- 63 = Organic Silts, Silt Clays - Low Plasticity - OL
- 71 = Inorganic Silts, Elastic Silts - High Plasticity - MH
- 72 = Inorganic Clays - High Plasticity - CH
- 73 = Organic Clays - Organic Silts - High Plasticity - OH
- 80 = Peat - PT
- 90 = Bedrock

SOILS - Subsurface: GC

% of Cell

6 - 10 - 00 = None
to
99 = 100%

SOILS - Subsurface: GF

% of Cell

6 - 20 - 00 = None
to
99 = 100%

SOILS - Subsurface: SC

% of Cell

6 - 30 - 00 = None
to
99 = 100%

SOILS - Subsurface: SF

% of Cell

6 - 40 - 00 = None
to
99 = 100%

SOILS - Subsurface: ML

% of Cell

6 - 61 - 00 = None
to
99 = 100%

SOILS - Subsurface: CL

% of Cell

6 - 62 - 00 = None
to
99 = 100%

SOILS - Subsurface: OL

% of Cell

6 - 63 - 00 = None
to
99 = 100%

SOILS - Subsurface: MH

% of Cell

6 - 71 - 00 = None
to
99 = 100%

SOILS - Subsurface: CH

% of Cell

6 - 72 - 00 = None
to
99 = 100%

SOILS - Subsurface: OH

% of Cell

6 - 73 - 00 = None
to
99 = 100%

SOILS - Subsurface: PT

% of Cell

6 - 80 - 00 = None
to
99 = 100%

SOILS - Subsurface: Bedrock

% of Cell

6 - 90 - 00 = None
to
99 = 100%

SOILS - Substratum

Class USCS

9 - 00 = None
- 10 = Gravels - GC
- 20 = Gravels - Silt/Clay - GF
- 30 = Sands, Sandy Gravels - SC
- 40 = Sands, Silt/Clay - SF
- 61 = Inorganic Silts and Very Fine Sands, Clayey Silts - Low Plasticity - ML
- 62 = Inorganic Clays, Sand Clays, Silty Clays - Low Plasticity - CL
- 63 = Organic Silts, Silt Clays - Low Plasticity - OL
- 71 = Inorganic Silts, Elastic Silts - High Plasticity - MH
- 72 = Inorganic Clays - High Plasticity - CH
- 73 = Organic Clays - Organic Silts - High Plasticity - OH
- 80 = Peat - PT
- 90 = Bedrock

SOILS - Substratum: GC

% of Cell

9 - 10 - 00 = None
to
99 = 100%

SOILS - Substratum: GF

% of Cell

9 - 20 - 00 = None
to
99 = 100%

SOILS - Substratum: SC

% of Cell

9 - 30 - 00 = None
to
99 = 100%

SOILS - Substratum: SF

% of Cell

9 - 40 - 00 = None
to
99 = 100%

SOILS - Substratum: ML

% of Cell

9 - 61 - 00 = None
to
99 = 100%

SOILS - Substratum: CL

% of Cell

9 - 62 - 00 = None
to
99 = 100%

SOILS - Substratum: OL

% of Cell

9 - 63 - 00 = None
to
99 = 100%

SOILS - Substratum: MH

% of Cell

9 - 71 - 00 = None
to
99 = 100%

SOILS - Substratum: CH

% of Cell

9 - 72 - 00 = None
to
99 = 100%

SOILS - Substratum: OH

% of Cell

9 - 73 - 00 = None
to
99 = 100%

SOILS - Substratum: PT

% of Cell

9 - 80 - 00 = None
to
99 = 100%

SOILS - Substratum: Bedrock

% of Cell

9 - 90 - 00 = None
to
99 = 100%

LAND FORMS

Predominant Type

0 = None
1 = Outwash Plain
2 = Beach Ridge
3 = Terraces (Alluvium)
4 = Ground Moraine
5 = Ground Moraine Over Outwash
6 = Till Plain
7 = Ground Moraine Over Glacial Lake Bed
8 = Glacial Lake and Lake Bed
9 = Sand Dunes
10 = Drumlins
11 = Eskers
12 = End Moraine
13 = Escarpment

RECREATION

Public Protected Lands

0 = None
1 = River or Lake Zoning (proposed)
2 = Scenic Easement
3 = Wildlife Preserve
4 = Military Reservation
5 = Indian Reservation
6 = State/Local Forest
7 = National Forest
8 = State/Local Park
9 = National Park

RECREATION - River or Lake Zoning

% of Cell
1 - 00 = None
to
99 = 100%

RECREATION - Scenic Easement

% of Cell
2 - 00 = None
to
99 = 100%

RECREATION - Wildlife Preserve

% of Cell

3 - 00 = None
to
99 = 100%

RECREATION - Military Reservation

% of Cell

4 - 00 = None
to
99 = 100%

RECREATION - Indian Reservation

% of Cell

5 - 00 = None
to
99 = 100%

RECREATION - State/Local Forest

% of Cell

6 - 00 = None
to
99 = 100%

RECREATION - National Forest

% of Cell

7 - 00 = None
to
99 = 100%

RECREATION - State/Local Park

% of Cell

8 - 00 = None
to
99 = 100%

RECREATION - National Park

% of Cell

9 - 00 = None
to
99 = 100%

RECREATION - Environmental Corridors

% of Cell

00 = None
to
99 = 100%

RECREATION - Scenic Highways

Number Per Cell

00 = None
to
99 = Number Per Cell

RECREATION - Landscape Resources

Dominant Type (Intrinsic)

0 = None
1 = Wildlife Resources
3 = Vegetative Resources
5 = Physiographic Resources
7 = Wetland Resources
9 = Water Resources

RECREATION - Intrinsic Resources/Wildlife

1 - 0 = None
- 2 = Birds
- 4 = Small Game
- 6 = Water Fowl
- 9 = Big Game

RECREATION - Intrinsic Resources/Vegetation

3 - 0 = None
- 1 = Berry Picking
- 2 = Unusual Crop
- 3 = Orchard
- 4 = Sugar Bush
- 5 = Wild Rice Area
- 6 = Wildflower
- 7 = Specimen (Trees, etc.)
- 8 = Virgin Stand (Timber)
- 9 = Prairie

RECREATION - Intrinsic Resources/Physiographic

5 - 0 = None
- 1 = Mineral Ore Outcropping
- 2 = Chasm
- 3 = Cave
- 4 = Balanced Rock
- 5 = Castle Rock
- 6 = Natural Bridge
- 7 = Exceptional Glacial Remains
- 8 = Highest Point in County
- 9 = Highest Point in County on Significant Topography

RECREATION - Intrinsic Resources/Wetland

7 - 0 = None
- 3 = Wildlife Observation
- 6 = Migration Stop-Over Point
- 9 = Exceptional Wetlands

RECREATION - Intrinsic Resources/Water

9 - 0 = None
- 2 = Fish Habitat
- 3 = Rapids, Whitewater
- 4 = Waterfall
- 5 = Exceptional River Island and Lake
- 7 = Great Lakes Island under 2 square mile
- 9 = Great Lakes Island over 2 square mile

RECREATION - Landscape Resources

Dominant Type (Extrinsic)

0 = None
1 = Topographic Associated Structures
2 = Camps and Trails
3 = Tourist Service Facilities
4 = Water Associated Sports and Facilities
5 = Winter Sports Facilities
6 = Public or Privately Owned Lands and Associated Clubs
7 = Water Associated Projects
8 = Wildlife and Conservation
9 = Cultural and Historical

RECREATION - Extrinsic Resources/Topographic Associated Structures

1 - 0 = None
- 3 = Fire Tower
- 6 = Observation Platform
- 9 = Lighthouse

RECREATION - Extrinsic Resources/Camps and Trails & Accommodati

2 - 0 = None
- 1 = Fire Breaks and Trails
- 2 = Bicycle Trail
- 3 = Bridle Trail
- 4 = Hiking Trail
- 5 = Nature Trail
- 6 = Trail Shelter
- 7 = Primitive Campgrounds
- 8 = Vehicle Campgrounds
- 9 = Day, Nature, and Youth Camps

RECREATION - Extrinsic Resources/Tourist Service Facilities

3 - 0 = None
- 1 = Disposal Stations
- 3 = Gas Stations
- 4 = Pharmacies
- 5 = Restaurant
- 6 = Accommodations
- 7 = Accommodations with Restaurants
- 9 = Hospital

RECREATION - Extrinsic Resources/Water Associated Sports and Facilities

4 - 0 = None
- 1 = Fuel, Repair, Supplies
- 3 = Harbor of Refuge
- 5 = Boating Facilities, Ramp
- 6 = Marina
- 7 = Harbor
- 8 = Swimming Facilities
- 9 = Bathing Beach

RECREATION - Extrinsic Resources/Winter Sports Facilities

5 - 0 = None
- 1 = Snowmobile Area
- 2 = Snow Play Area; Sledding, etc.
- 3 = Ice Skating Shelter
- 4 = Ski Trail (Cross Country)
- 6 = Ski Trail
- 7 = Ski Rope Tow
- 8 = Ski Lift
- 9 = Ski Slope Structure

RECREATION - Extrinsic Resources/Publicly or Privately Owned Lands and Associated Clubs

6 - 0 = None
- 1 = Gun and Sportsmen's Club
- 2 = Archery Range
- 3 = Rifle Range
- 4 = Polo Field
- 5 = Picnic Area, Wayside
- 6 = Golf Course
- 7 = Golf Club
- 8 = Airfield, Rural
- 9 = Airfield, Urban

RECREATION - Extrinsic Resources/Water Associated Projects

7 - 0 = None
- 1 = Wetland Project, Levee, Ditch, Dyking
- 3 = Dam, Fishways, Drainageway
- 5 = Canal
- 7 = Lock

RECREATION - Extrinsic Resources/Wildlife and Conservation

8 - 0 = None
- 2 = Outstanding Reforestation Project
- 4 = Game Farm
- 6 = Fish Hatchery
- 8 = Wildlife Hunting or Hunting Preserve

RECREATION - Extrinsic Resources/Cultural and Historical

9 - 0 = None
- 2 = Historical Structure
- 4 = Historical Feature
- 6 = Cultural Structure
- 8 = Cultural Feature

RECREATION - Extrinsic Resources/Historical Structure

9 - 2 - 0 = None
- 1 = Log Cabin or Barn
- 2 = Frame Structure Prior 1869 Associated with Famous Person or Event
- 3 = Opera House
- 4 = Old Mine
- 5 = Old Mill
- 6 = Covered Bridge
- 7 = Lumber Camp
- 8 = Historical Home, Church, or School
- 9 = Old Fort

RECREATION - Extrinsic Resources/Historical Feature

9 - 4 - 0 = None
- 1 = Historical Folk Lore
- 3 = Mill Pond
- 5 = Historical Markers
- 7 = Battlefields
- 9 = Old Cemetery

RECREATION - Extrinsic Resources/Cultural Structure

9 - 6 - 0 = None
- 1 = Tavern, Saloon
- 2 = Antique Shop
- 3 = Restaurant (Unusual - Native Dishes)
- 4 = Museum
- 5 = Theatre
- 6 = Outstanding Building
- 7 = Military Academy
- 8 = School of Higher Education or Seminary
- 9 = Modern Mill or Mine

RECREATION - Extrinsic Resources/Cultural Features

9 - 8 - 0 = None
- 1 = Commercial Fishing
- 3 = Race Trace
- 4 = Car Ferry
- 5 = Native Handicraft (Craftsmens' Shop)
- 7 = Outstanding Farmer Market
- 8 = Local Festival Celebration
- 9 = County Fair

AVERAGE DAILY TRAFFIC

Number of Vehicles/Day

0 = None
1 = 15,501 Plus
2 = 8,501 - 15,500
3 = 6,501 - 8,500
4 = 4,001 - 6,500
5 = 2,501 - 4,000
6 = 851 - 2,500
7 = 551 - 850
8 = 186 = 550
9 = 1 - 185

ENVIRONMENTAL AWARENESS CENTER

Milwaukee-Green Bay Interstate

TEST CASE

TEST ELEMENTS

Proposed Routes

0 = None
1 = A
2 = B
3 = C
4 = D
5 = E
7 = D + A
8 = B + C + A
9 = D + C + B + A

THREE CORRIDORS

0 = None
1 = A
3 = B
4 = B + A
5 = C
6 = C + A
8 = C + B
9 = C + B + A

ENVIRONMENTAL AWARENESS CENTER

Milwaukee-Green Bay Interstate Variables

CONSTRAINTS

SOCIAL POLITICAL UNITS - Counties

Name

1 - 0 = None
1 - 1 = Brown
1 - 2 = Outagamie
1 - 3 = Kewaunee
1 - 4 = Manitowoc
1 - 5 = Calumet
1 - 6 = Winnebago
1 - 7 = Fond du Lac
1 - 8 = Sheboygan
1 - 9 = Dodge
2 - 0 = Washington
2 - 1 = Ozaukee

SOCIAL POLITICAL UNITS/BROWN COUNTY - Townships

Name

1 - 1 - 0 - 0 = None
- 0 - 1 = Howard
- 0 - 2 = Hobart
- 0 - 3 = Lawrence
- 0 - 4 = Wrightstown
- 0 - 5 = Holland
- 0 - 6 = Morrison
- 0 - 7 = Rockland
- 0 - 8 = Bellevue
- 0 - 9 = Allouez
- 1 - 0 = New Denmark
- 1 - 1 = Glenmore
- 1 - 2 = Suamico
- 1 - 3 = Scott
- 1 - 4 = City of Green Bay
- 1 - 5 = De Pere
- 1 - 6 = Ashwaubenon
- 1 - 7 = Pittsfield
- 1 - 8 = Eaton

SOCIAL POLITICAL UNITS/ OUTAGAMIE COUNTY - Townships

Name

1 - 2 - 0 = None
- 1 = Oneida
- 2 ==Seymour
- 3 = Kaukauna
- 5 = Vandenbroek
- 7 = Buchanan
- 8 = Grand Chute
- 9 = Freedom

SOCIAL POLITICAL UNITS/ KEWAUNEE COUNTY - Townships

Name

1 - 3 - 0 - 0 = None
- 0 - 5 = Franklin

SOCIAL POLITICAL UNITS/ MANITOWOC COUNTY - Townships

Name

1 - 4 - 0 - 0 = None
- 0 - 1 = Maple Grove
- 0 - 2 = Coopers Town
- 0 - 3 = Franklin
- 0 - 4 = Cato
- 0 - 5 = Rockland
- 0 - 6 = Gibson
- 0 - 7 = Kossuth
- 0 - 8 = Manitowac Rapids
- 0 - 9 = Newton
- 1 - 0 = Liberty
- 1 - 1 = Eaton
- 1 - 2 = Two Rivers
- 1 - 3 = Manitowac
- 1 - 4 = Schleswig
- 1 - 5 = Meeme
- 1 - 6 = Centerville
- 1 - 7 = Two Creeks
- 1 - 8 = Mishicot

SOCIAL POLITICAL UNITS/CALUMET COUNTY - Townships

Name

1 - 5 - 0 - 0 = None
- 0 - 1 = Harrison
- 0 - 2 = Woodville
- 0 - 3 = Brillion
- 0 - 4 = Rahtoul
- 0 - 5 = Stockbridge
- 0 - 6 = Chilton
- 0 - 7 = Charlestown
- 0 - 8 = Brothertown
- 0 - 9 = New Holstein

SOCIAL POLITICAL UNITS/WINNEBAGO COUNTY - Townships

Name

1 - 6 - 0 - 0 = None
- 0 - 1 = Menasha
- 0 - 2 = Neenah
- 0 - 3 = Vinland
- 0 - 5 = Oshkosh
- 0 - 7 = Algoma
- 0 - 8 = Nekimi
- 0 - 9 = Black Wolf

SOCIAL POLITICAL UNITS - State Senatorial Districts

Number

0 = None
1 = Senate District 1
2 = Senate District 2
3 = Senate District 13
4 = Senate District 14
6 = Senate District 18
7 = Senate District 19
8 = Senate District 20
9 = Senate District 30

EAC Variables - CONSTRAINTS (Continued)

SOCIAL POLITICAL UNITS - State Assembly Representation

Number
0 = None
3 = (Kewaunee, Calumet, Washington, Ozaukee) 1
6 = (Manitowoc, Sheboygan, Fond du Lac, Dodge) 2
9 = (Brown, Outagamie, Winnebago) 3

SOCIAL POLITICAL UNITS - Congressional Districts

Number
0 = None
1 = Congressional District 2
5 = Congressional District 6
9 = Congressional District 8

SOCIAL POLITICAL UNITS - Cooperative Educational Service Agency Districts

Number
0 = None
1 = CESA 8
3 = CESA 9
4 = CESA 10
5 = CESA 13
7 = CESA 16
9 = CESA 19

SOCIAL POLITICAL UNITS/CESA 8 - School Districts

Name
1 - 0 - 0 = None
- 0 - 1 = Little Chute
- 0 - 2 = Kimberly
- 0 - 3 = Kaukauna
- 0 - 4 = Freedom
- 0 - 6 = Appleton
- 0 - 7 = Menasha
- 0 - 8 = Neenah
- 0 - 9 = Oshkosh
- 1 - 0 = Winnecone

SOCIAL POLITICAL UNITS/ CESA 9 - School Districts

Name

3 - 0 - 0 = None
- 0 - 1 = Wrightstown
- 0 - 2 = DePere East
- 0 - 3 = Denmark
- 0 - 4 = Ashwaubenon
- 0 - 5 = DePere West
- 0 - 6 = Green Bay
- 0 - 7 = Luxemburg-Casco
- 0 - 8 = Howard-Suamico
- 0 - 9 = Pulaski
- 1 - 0 = Seymour

SOCIAL POLITICAL UNITS/ CESA 10 - School Districts

Name

4 - 0 - 0 = None
- 0 - 1 = Kiel
- 0 - 2 = Chilton
- 0 - 3 = Valdens
- 0 - 4 = Manitowoc
- 0 - 5 = Two Rivers
- 0 - 6 = Stock Bridge
- 0 - 7 = Hilbert
- 0 - 8 = Brillion
- 0 - 9 = Reedsville
- 1 - 0 = Cedar Grove
- 1 - 1 = Mishicot
- 1 - 2 = New Holstein
- 1 - 3 = Random Lake
- 1 - 4 = Elkhart Lake
- 1 - 5 = Howards Grove
- 1 - 6 = Sheboygan
- 1 - 7 = Kohler
- 1 - 8 = Sheboygan Falls
- 1 - 9 = Plymouth
- 2 - 0 = Oostburg

SOCIAL POLITICAL UNITS - Regional Planning Districts

Name

0 = None
3 = Northeast Wisconsin Regional Planning Commission
5 = Brown County Regional Planning Commission
7 = Fox Valley Council of Governments
8 = Fox Valley Council of Governments & Northeast Wisconsin Regional Planning Commission
9 = Southeast Wisconsin Regional Planning Commission

LAND OWNERSHIP

Number of Owners/Grid

0 = None
1 = Number of Owners
to
98 = Number of Owners
99 = Urbanized Area

POPULATION CENERS

Population Groupings

0 = None
1 = Less than 400
2 = 400 - 600
3 = 600 - 800
4 = 800 - 1,200
5 = 1,200 - 2,500
6 = 2,500 - 5,000
7 = 5,000 - 10,000
8 = 10,000 - 45,000
9 = 45,000 - Plus

POPULATION CENTERS - Less than 400

Population Centers

1 - 0 = None
- 5 = Eden Village (312)
- 9 = Adell Village (398)

POPULATION CENTERS - 400-600

Population Centers

2 - 0 = None
- 1 = Waldo Village (403)
- 2 = Whitelaw Village (420)
- 3 = Glenbeulah Village (428)
- 5 = Cascade Village (447)
- 7 = Jackson Village (458)
- 8 = Stockbridge (476)
- 9 = St. Cloud Village (530)

POPULATION CENTERS - 600-800

Population Centers

3 - 0 = None
- 1 = Germantown Village (622)
- 2 = Valders Village (622)
- 3 = Belgium (643)
- 4 = Elkhart Lake Village (651)
- 5 = St. Nazianz (669)
- 6 = Cleveland Village (687)
- 7 = Fredonia (710)
- 8 = Hilbert (736)
- 9 = Mishicot (762)

POPULATION CENTERS - 800-1,200

Population Centers

4 - 0 = None
- 1 = Lomira Village (807)
- 2 = Reedsville (830)
- 3 = Wrightstown (840)
- 4 = Random Lake (858)
- 5 = Saukville (1,038)
- 6 = Oostburg (1,065)
- 7 = Denmark (1,106)
- 8 = Slinger (1,141)
- 9 = Cedar Grove (1,175)

POPULATION CENTERS - 1, 200 - 2, 500

Population Centers

5 - 0 = None
- 1 = Combined Locks (1, 421)
- 2 = Campbellsport (1, 472)
- 3 = Kohler (1, 529)
- 5 = Barton (1, 569)
- 7 = Kewaskum (1, 572)
- 8 = Brillion (1, 783)
- 9 = New Holstein (2, 401)

POPULATION CENTERS - 2, 500 - 5, 000

Population Centers

6 - 0 = None
- 1 = Thiensville (2, 507)
- 2 = Kiel (2, 524)
- 3 = North Fond du Lac (2, 549)
- 4 = Chilton (2, 578)
- 6 = Bayside (3,181)
- 8 = Grafton (3, 748)
- 9 = Sheboygan Falls (4, 061)

POPULATION CENTERS - 5, 000 - 10, 000

Population Centers

7 - 0 = None
- 1 = Little Chute (5, 099)
- 2 = Plymouth City (5,128)
- 3 = Cedarburg (5,191)
- 4 = Kimberly (5, 322)
- 5 = Hartford (5, 627)
- 6 = Port Washington (5, 984)
- 8 = Mequon (8, 543)
- 9 = West Bend (9, 969)

POPULATION CENTERS - 10, 000 - 45, 000

Population Centers

8 - 0 = None
- 1 = DePere (10, 045)
- 2 = Kaukauna (10, 096)
- 4 = Two Rivers (12, 393)
- 5 = Menasha (14, 647)
- 6 = Neenah (18, 057)
- 8 = Manitowoc (32, 275)
- 9 = Fond du Lac (32, 719)

POPULATION CENTERS - More than 45, 000

Population Centers

9 - 0 = None
- 1 = Oshkosh (45, 110)
- 3 = Sheboygan (45, 747)
- 5 = Appleton (48, 411)
- 9 = Green Bay (62, 888)

DRAINAGE AREAS - Major River Sub-Basins

Sub-Basin Name and Code

0 = None
1 = Fox River Basin (WIS-GL-SL-L. Mich. -5h)
3 = Fond du Lac River Basin (WIS-GL-SL-L. Mich. -5hl)
5 = Milwaukee River Basin (WIS-GL-SL-L. Mich. -5g)
7 = Rock River Basin (WIS-UM-Rock-21)
8 = Illinois River Basin (WIS-UM-Ill-28b)
9 = Lake Michigan Basin (WIS-GL-SL-L. Mich. -5)

UTILITIES - Telephone Cable

Number Per Cell

1 - 00 = None
to
- 99 = Number Per Cell

UTILITIES - Gas Lines 3" - 14"

Number Per Cell

3 - 00 = None
to
- 99 = Number Per Cell

UTILITIES - Gas Lines 16" - 24"

Number Per Cell

4 - 00 = None
to
- 99 = Number Per Cell

UTILITIES - High Pressure Oil Lines

Number Per Cell

5 - 00 = None
to
- 99 = Number Per Cell

UTILITIES - Power Transmission Lines

Number Per Cell

6 - 00 = None
to
- 99 = Number Per Cell

UTILITIES - Railway Lines

Number Per Cell

9 - 00 = None
to
- 99 = Number Per Cell

DRAINAGE AREAS/FOX RIVER BASIN (WIS-GL-SL-5h) - Watersheds

Watershed

1 - 00 = None
- 01 = East River (19)
- 03 = Lower Fox River (18)
- 05 = Arrowhead River (17)
- 07 = Fox River (16)
- 09 = Fisk Branch, Rush Creek (15)

DRAINAGE AREAS/FOND DU LAC RIVER BASIN (WIS-GL-SL-L. Mich. - 5hl) - Watersheds

Watershed

3 - 00 = None
- 03 = Lake Winnebago - Shore Drainage (4-3)
- 06 = Fond du Lac River (2)
- 09 = East Branch, Fond du Lac River (1)

DRAINAGE AREAS/MILWAUKEE RIVER BASIN (WIS-GL-SL-L. Mich. -5g) - Watersheds

Watershed

5 - 00 = None
- 01 = West Branch, Milwaukee River (1)
- 02 = Lower West Branch, Milwaukee River (2)
- 03 = East Branch, Milwaukee River (3)
- 04 = North Branch, Milwaukee River (4)
- 05 = Sucker Creek (8)
- 07 = Sauk Creek (7)
- 08 = Milwaukee River (6)
- 09 = Cedar Creek (5)

DRAINAGE AREAS/ROCK RIVER BASIN (WIS-UM-Rock-21) - Watersheds

Watershed

7 - 00 = None
- 01 = Bark River (9)
- 03 = Oconomowoc River (6)
- 05 = Ashippun River (5)
- 07 = Rubicon River (4)
- 09 = East Branch, Rock River (2)

DRAINAGE AREAS/ILLINOIS RIVER BASIN (WIS-UM-Ill-28b) - Waters

Watershed

8 - 00 = None
- 05 = Upper Fox River (1)

DRAINAGE AREAS/LAKE MICHIGAN BASIN (WIS-GL-SL-L. Mich. -5) - Watersheds

Watershed

9 - 00 = None
- 01 = Duck Creek (24)
- 02 = Bay Shore Drainage (23)
- 03 = East Twin River (18)
- 04 = Twin River (17)
- 05 = Branch River (15)
- 06 = Manitowoc River (14)
- 07 = Kill Snake and South Branch Manitowoc (13)
- 08 = Lower Manitowoc River (16)
- 09 = Seven Mile Creek (12)
- 10 = Pigeon River (11)
- 11 = Sheboygan River (10)
- 12 = Mullet and Onion Rivers (9)
- 13 = Black River (8)
- 14 = Menomonee River (7)

THE CORRIDOR DETERMINANT PROCESS

Initially, the variables were grouped into nine "corridor determinants," as shown in Enclosure 2. These reflect the basic economic, social, and environmental determinants used in highway location. Each variable was assigned a weighting by establishing the intra-relationship between the selected variables within that "determinant" grouping only. No attempt was made at this point to relate variables between the nine corridors or to inter-relate groupings. The output then became a reduction of the total variable list into nine groups of variables--corridor determinants--which provided for variable manipulation to select a single highway corridor.

The second phase of the analysis is a matter of relating one corridor determinant to another and by various weightings arriving at a corridor based upon a selected value system. Due to the speed of the computer, it is possible to program a multitude of relationships and search for congruency among them. The various graphic outputs then become the "tool" of highway location: (1) the print-outs provided graphic displays of corridor desirability; and (2) data manipulation provided the opportunity to reflect areas which are consistently desirable, indicating areas of least conflict, and those areas of greatest conflict. The combination of manipulation and graphic displays provided the decision-makers with the means to resolve conflicts rapidly and systematically look for alternatives.

Enclosure 2 (Continued)

Highest Engineering Capabilities for Highways

Variables

- 0-2% Slope
- 3-6% Slope
- 7-12% Slope
- 13-20% Slope
- 21%+ Slope
- Subsurface Soils
- Substratum Soils
- Change in Elevation
- No Slope
- One Slope
- Two Slopes
- Three Slopes
- Four Slopes

Least Construction Costs for Highways

- % Upland Forest
- % Lowland Forest
- % Swamp
- Intermittent Streams
- Streams
- Minor River
- Major River
- Pond
- Lake
- Lake Michigan
- Limited Access Highways
- Transmission Lines
- Gas Lines 3-15"
- Gas Lines 16-24"
- High Pressure Oil Lines
- Telephone
- Railroad
- Paved Town Roads
- Paved County Roads
- State Highways
- Federal Highways
- Interchanges

Least Damage by Highways to Ecological Systems

- Intermittent Stream
- Stream
- Minor River
- Major River
- Pond
- Lake
- Lake Michigan
- Barren Land
- Upland Forest
- Lowland Forest
- Open Swamp
- Four Slopes
- 3-6% Slope
- 7-12% Slope
- 13-20% Slope
- 21%+ Slope
- Elevation Change
- Soils

Greatest Need for Highway

This analysis is based on origin-destination data; the number of people leaving or arriving per square mile. This is a single variable data ma analysis.

NINE CORRIDOR DETERMINANTS:

Least Acquisition Cost for Highway Location

Variables

Residential-Rural
Residential-Vacation
Residential-Suburban
Residential-Urban
Proposed Residential
Proposed Industrial
Proposed Institutional
Limited Access Highway
Interchange
Railroad
Surface Soils
Subsurface & Substratum Soils

Commercial
Industrial
Recreation
Institutional
Proposed Commercial
Proposed Recreational
Town Road Unpaved
Town Road Paved
County Road
State Highway
Federal Highway
Land Owners

Least Damage to Potential Conservation and Recreation Lands

Variables

River or Lake Zoning
Intermittent Stream
Streams
Minor Rivers
Major River
Pond
Lake
Lake Michigan
Scenic Highway
Degree of Orientation
Drumlins
End Moraine
Intrinsic Resources
Elevation Change

Barren Land
Upland Forest
Lowland Forest
Open Swamp
0-2% Slope
3-6% Slope
7-12% Slope
13-20% Slope
21% + Slope
Sand Dunes
Eskers
Escarpment
Extrinsic Resources

Enclosure 2 (Continued)

Areas Most Scenic from a Highway

Variables

Barren Land
Upland Forest
Lowland Forest
Open Swamp
0-2% Slope
3-6% Slope
7-12% Slope
13-20% Slope
21%+ Slope
Drumlins
End Moraine
Intrinsic Resources

Agriculture
All Water
Small Towns
One Slope
Two Slopes
Three Slopes
Four Slopes
Elevation Change
Sand Dunes
Eskers
Escarpment
Extrinsic Resources

Least Resistance to Highway Location

Variables

Residential-Rural
Residential-Vacation
Residential-Suburban
Residential-Urban
Institutional
Proposed Residential
Proposed Commercial
Proposed Recreation

Commercial
Industrial
Recreation
Number of Landowners
Agricultural
Proposed Institutional
Proposed Industrial

Least Destruction to Productive Agriculture Lands

Variables

0-2% Slope
3-6% Slope
7-12% Slope
Subsurface & Substratum-GC
Subsurface & Substratum-GF
Subsurface & Substratum-SC
Subsurface & Substratum-SF
Subsurface & Substratum-ML
Subsurface & Substratum-CL
Subsurface & Substratum-CH
Subsurface & Substratum-Bedrock

Surface-GF
Surface-SC
Surface-SF
Surface-ML
Surface-CL
Surface-OL
Surface-CH
Surface-PT
Subsurface & Substratum-OL
Subsurface & Substratum-PT

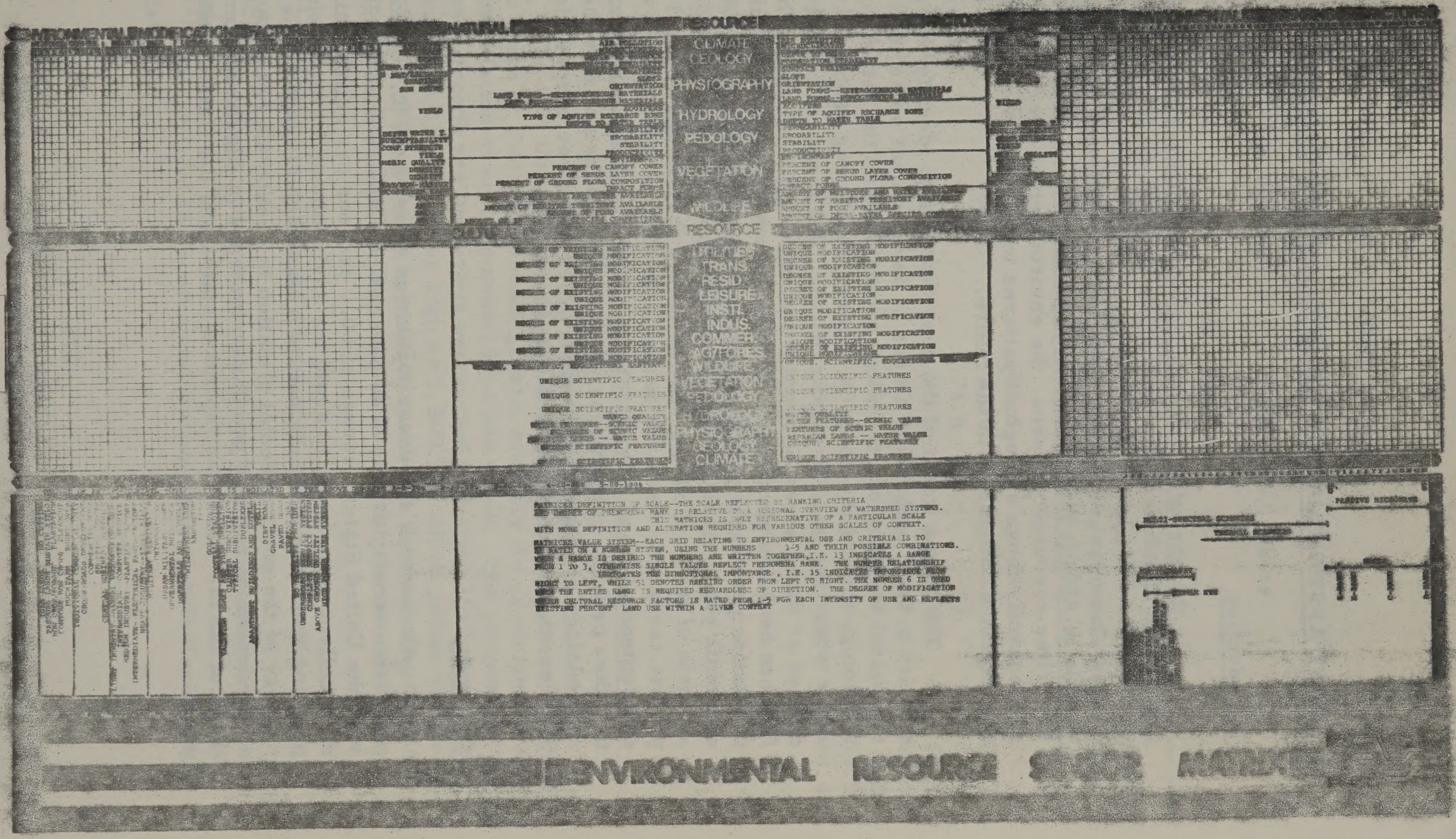
Research Potential

The ultimate goal of the Center staff is to have the ability to predict the social, economic, aesthetic, and ecological effects of land use decisions upon man and his environment before heavy investing in physical implementation. With the variety of interests of our team directed toward one major finding, we have been even more engrossed by the possibilities our research has uncovered. The Interstate and other prior studies have provided an opportunity to establish a method and data bank from which the described goal can be obtained.

The ability to reach our objective is dependent upon increasing amounts of research or multidisciplinary team effort, the (process) of hard data collection, storage and manipulation.

One important point does stand out clearly from our initial team research: Our data collection bank, when expanded on a state-wide basis and constantly up-dated, could be available to innumberable local, state and federal groups for any number of planning decisions. State-wide planning and projection, stored in a computer bank, could become a most predictive, revolutionary, and easily and quickly usable form of research. Vast quantities of data also require increased involvement with data manipulation and display computer programs. The combination of new forms of data retrieval, manipulation and display for use in data banks for environmental management decision-making is a research task which must be realized if the environment and its participants are to prosper in an improved, well-planning and protected ecological environment.

Additional emphasis is being placed on the role of air-borne sensor equipment and techniques to record resource data identified in this report. Page 85 illustrates an environmental resource sensor matrix being developed by graduate students Michael McCarthy and Stephen Dunn under the direction of Prof. Bernard Niemann.



APPENDIX E.

FIRST APPROXIMATION ENVIRONMENTAL OVERVIEW: ALASKA

Introduction

In the spring of 1969 the University of Wisconsin completed in a limited six month first approximation study an environmental overview of the State of Alaska. The research was commissioned by the Land Law Review Commission and was directed at identifying within the vast public domain of Alaska the areal and linear patterns of man's cultural impact, the prime resource patterns, the environmental corridor patterns and subsequently those ecological patterns which have been modified and can expect modification in the future.

The prime intent of the overview was to identify these patterns of conflict in their embryonic stages of development so as to direct detailed ecological inventories, technical expertise, and the latest scientific technology toward the solution of these developing problems in those areas where the need is most critical. The term critical areas being defined as those areas of present and expected conflict which were found to be definable through correlations with ecological suitability, population patterns, wildlife patterns, mineral extraction and other economic projections and land use patterns. In a state with such vast amounts of land resources it is essential that State, Federal and private research, research funds, scientific technology and environmental plans concentrate on areas which are not so extensive that they prohibit comprehensiveness. This substantiates the methodology of this environmental overview whose purpose is to point out these areas of prime consideration.

Concepts

Alaska with a present population of around 272, 000 and a population density of only 0. 40 persons per square mile compared with the United States average of 60. 0 persons per square mile offers an excellent opportunity to avoid the environmental errors which are plaguing the more intensely settled areas of the United States. The urgency of the environmental situation is greatly increased by looking at the decennial rates of population increase in Alaska as compared to those of the far West, the mountain states and the United States as a whole.

Decennial Rates Of Population Increase--Alaska, West, Mountain States And Total United States

1880 - 1960

Decennial Period	Alaska %	Far West[1] %	Mountain[2] %	United States[3] %
1880-1890	-4.1	64.5	113.1	25.5
1890-1900	98.4	27.0	43.1	20.7
1900-1910	1.2	73.8	53.7	21.0
1910-1920	-14.5	32.1	26.9	14.9
1920-1930	7.7	46.8	7.3	16.1
1930-1940	22.3	18.8	9.3	7.2
1940-1950	77.4	48.8	15.8	14.5
1950-1960	75.8	55.5	23.9	18.4

Source: Institute of Business, Economic and Government Research, Alaska's Population and Economy (Economic Series: Publication No. 1, Vol. I, University of Alaska: 1963)

Table E. 1

The fact that almost all of Alaska is in public ownership (95%) either State or Federal, should greatly simplify the development and implementation of environmental land use plans. The projections for Alaska's growth are numerous and varied with year 1980 predictions ranging from 339,000 to as high as 1,800,000 which points out the uncertainty of the experts in predicting Alaska's economic potential and growth. The Prudhoe Bay oil discovery with its tremendous impact on Alaska's economy and the environment of the Arctic north shore is an example of this unpredictability of man's impact in Alaska by conventional economic models. The potential impact of the increasingly affluent Japanese is another impact which must be considered in the future.

---

[1] Far West includes the States of Washington, Oregon, California and Nevada.

[2] Mountain includes Montana, Idaho, Wyoming, Utah and Colorado.

[3] Population of the continental United States (excluding Alaska and Hawaii).

These conclusions led the research team to the use of prime resources and ecological patterns as a base for conflict predictions. These form determinant patterns existing as a result of the climatic and topographic extremes of Alaska are easily definable and led to the development of several hypotheses which were used in the synthesis and design phase of the overview which are shown in the following sectio

Methodology

The Alaska Environmental Overview was organized and completed in four phases as shown below.

Phase I - Feasibility Investigations: This phase of the overview consisted of the establishment of the goals, scope, base maps and graphic presentation to be used.

Phase II - Inventory: This phase consisted of the identification, location, and mapping of the prime cultural and natural patterns of the environment.

Phase III - Analyzation: This phase consisted of the identification of correlations found existing between the cultural and natural resource patterns (Maps 1-4).

Phase IV - Environmental Synthesis And Design: This phase consisted of the interpretation of existing and projected ekistic growth patterns and their impact on the environment (areas of potential resource conflicts) based on the correlations observed in Phase III. This interpretation is shown on Map 5.

In the following sections of this brief synopsis, Phases I, II, III and IV have been separated and analyzed in terms of their components.

In the Phase I investigations the research team, after establishing the goals and scope of the project, determined what base maps and scales should be utilized for the overview analysis. These were:

Original Base Maps	Scale
U.S. Department of Commerce, Coast and Geodetic Survey base acetates, 1966	1:500,000
U.S. Aernautical Chart and Information Center, U.S. Air Force, Operational Navigation Charts, 1967	1:1,000,000
Numerous unpublished and published maps	1:2,500,000
Final Presentation Maps	
Maps 1-5 (enclosed)	1:2,500,000

In the inventory phase, environmental variables that were available for the totality of Alaska were identified and mapped. These variables were:

Component	Variables
1	Environmental corridors (water, wetlands)
2	Ecological systems (six prime systems defined by ecologist A. W. Kuchler).
3	Topography (500' contour intervals)
4	Drainage pattern
5	Human impact
6	Wildlife patterns (based on prime habitat)
7	Fisheries (based on prime marine habitat and anadromous fisheries)
8	Disposition of public land
9	Locatable and leasable minerals

In the analyzation phase of the overview the combining and correlation process of Phase II data was completed, disclosing and delineating those areas of existing resource conflicts and those areas with future potential for conflict. The results of this analysis are illustrated by Maps 1-4 of the overview.

Map 1 Man's Impact On The Natural Eco-Types Of Alaska

This map was designed to graphically illustrate the correlations existing between man's impact (native, urbanized and mineral extractio and the major eco-systems, water, wetland, and topographic patterns of the environment.

Map 2 Man's Impact On The Prime Fisheries And Wildlife Habitat Of Alaska

This map was designed to graphically illustrate the correlations between man's impact and the major eco-systems, prime fisheries, prime wildlife habitat and environmental corridor elements of the natural environment.

Map 3 Potential Impact Of Mineral Extraction On The Natural Eco-Types

This map illustrates the correlations existing between the potential impact of mineral extraction on the natural eco-systems (includes environmental corridor). Another important correlation that was made from this map was the designation of those areas of human impact which have developed as the direct result of mineral extraction.

Map 4 Potential Impact Of Mineral Extraction Upon The Fisheries, Wildlife And Natural Environment

This map was designed to graphically illustrate the correlation or conflict patterns found between the existing and potential impact of mineral extraction and the prime fisheries and wildlife habitat.

In the synthesis and design phase (Phase IV) the correlations found in Phases I-III were used in the synthesis and design of Map 5 - Interpretation Of Existing And Projected Land Use Conflicts In Alaska.

Premise 1 - With increases in precipitation, temperature, potential evapo-transpiration and decreases in latitude and altitude the eco-systems become increasingly more complex and mature.

Correlation - Man's impact in Alaska occurs primarily within the more complex interior upland forest and coastal forest eco-systems and can be expected to develop within these more complex systems.

Correlation - Within these eco-systems the environmental corridor (water, wetland patterns) further defines the cultural impact (urbanized)(4) and environmental complexity. (5) This correlation further substantiates Professor Philip H. Lewis' findings in Wisconsin indicating that 80-90% of our natural and cultural features fall within these corridors. This premise was found to be true in Alaska also.

Correlation - With decreases in ecological complexity as a result of climatic extremes the eco-systems become more fragile and man's impact will have much greater and long range effects. The most common impacts found on the more fragile eco-systems (Arctic tundra, Alpine tundra, maritime tundra) are mineral extraction, native subsistance and commercial hunting and fishing.

Correlation - Another important ecological correlation was found in the complex coastal forest eco-system. It was discovered that even though a complex and rather stable environment exists in this eco-system it was still possible for serious environmental deterioration to exist with poor forest management. This deterioration is due in part to the extreme amounts of precipitation (up to 220 inches per year) that this eco-system receives and the erosion potential that exists when the forest cover has been stripped and logging roads built in all directions. It is possible however since these forests are a renewable resource and rapidly replenish themselves on this complex eco-system to limit the amount of damaged to the ecology by using the latest and best ecologically oriented management procedures.

---

(4) Urbanized impact is referred to as the area affected by incorporated and unincorporated cities, towns, villages, urban sprawl, military development, seasonal housing (vacation), hunting and recreation development along with the coexisting transportation and utility development.

(5) The increase in environmental complexity found within the corridor pattern is primarily due to the increasingly more complex vegetation, soils and wildlife patterns which are found in proximity to water and the more readily excessible water table and subsequently increased evapo-transpiration cycle.

Premise 2 - Man's impact on the Alaskan environment was presently found to consist of three primary classifications and relative degrees of impact. These classifications have been separated and color coded to indicate the type and degree of impact on the environment.

Description	Degree Of Impact
Urbanization and area affected(6)	1st Degree
Mineral extraction and area affected	2nd Degree
Native impact and area affected	3rd Degree

Premise 3 - The delineation of new resource discoveries and impact are very difficult to predict but the oil and gas provinces of Alaska are known and as a generalization it was found that future mineral extraction impact will occur in those areas where minerals have previously been located and/or mined. (7)

Correlation - Areal distribution of previous mining sites and related development (trails, mines, camps) provide the most reliable base for predictions of future mineral extraction impact at the overview stage. The specific impacts resulting from mining or mineral extractio are covered in Chapter II, Section E. of this volume.

---

(6) The area affected by the three classes of impact was determined by delineating the fringe areas of development found in the rural areas surrounding the main area of impact.

(7) The correlation of potential mineral extraction impact being based on known and previously mined sites is founded on the statement of Charles F. Herbert, Deputy Commissioner of the Alaska State Department of Natural Resources at the 1964 Alaska A. I. M. E. Conference.

Premise 4 - The future growth of urbanization, native and mineral extraction impacts were found to generally follow the patterns of existing transportation and rural development along the eco-systems and environmental corridors mentioned in Premise 1. This probable direction is shown on Map 5 by small arrows.

Correlation - Native impact will generally decrease except around the larger native villages where the natives are turning from subsistance to commercial hunting, trapping and fishing as shown by the Federal Field Committee's report Alaska Natives And The Land.

Correlation - Permafrost and climatic extremes will restrict urbanization from the more northern areas of Alaska except in those areas where mineral extraction, native subsistance, commercial and trophy hunting and fishing impact occur.

Correlation - Most urbanization will occur along transportation systems from Fairbanks to Anchorage and along the Alaskan Highway from Fairbanks south. The state selections in these areas will also stimulate development as is already occurring in the southern panhandle of Alaska.

Correlation - The building of a 40 inch pipe line and road from Fairbanks to the north shore oil fields will provide a development corridor which will open up many new areas of cultural impact in areas which are presently in a wilderness state. A great deal of research and study is needed in these areas to insure that the ecological balance is not disturbed.

Summary

In conclusion Maps 1-4 were designed to illustrate the correlations existing between man's impact and the natural environment. Map 5 was developed as a result of the synthesis of these four maps. Its purpose was to clearly delineate in a first approximation overview those areas where development is presently in conflict with the environment along with the areas where potential conflicts could occur. The environmental overview by clearly delineating existing and potential environmental problem areas is an excellent planning tool for federal, state and local administrators and policy makers to use in developing environmental priorities and goals.

It should also be pointed out that this first approximation overview because of the lack of statewide inventory data only indicates those areas of impact and potential impact on the environment. The next step in proper environmental planning would be to establish in a first approximation overview those areas of greatest diversity within the state by means of detailed environmental quality inventories as explained in detail in Chapter VI of this report. The final steps would be to conduct detailed ecological and other environmental inventories and studies in those areas designated by the 1st and 2nd stage environmental overviews. Examples of these detailed studies and inventories using remote sensing and systems analysis have been described in previous sections of this report.

(followed by title p. of Section B)

SECTION B:

A General System For Environmental Resource Analysis

A REPORT TO THE
PUBLIC LAND LAW REVIEW COMMISSION

STEINITZ ROGERS ASSOCIATES INC
CAMBRIDGE MASSACHUSETTS

FOREWORD

The prime objective of our two reports is the improvement of decision making in agencies with responsibilities for public lands so that the resource qualities of these public lands can be maintained and enhanced. The studies present descriptions of methods for the identification of these significant environmental resources and qualities and the determination of the impacts of their use. Two approaches to environmental analysis are presented, each of which can be supportive of the other.

Environmental Quality and The Public Lands presents the approach developed by Landscapes Inc. These methods are essentially holistic, seeking patterns of landform which should influence the quantities and qualities of resource use which can be applied to land, and in particular public lands. The approach describes the requirements of an inventory and analysis system for bringing together contributions of the behavioral, natural, and physical sciences with "form determininants" from the engineering and planning design fields. The methods emphasize the use of existing personnel and administrative structures as well as the analysis of known information. Techniques for education -- environmental awareness -- are seen as a fundamental requirement for increasing the awareness in both the general public and the responsible agencies, of the value of these environmental resource qualities. Examples of the application of these methods are included.

In A General System for Environmental Resource Analysis the Steinitz Rogers group presents the methods which they have developed for comprehensive environmental resource inventories and analyses, with particular emphasis on the analysis of impacts of land use on environmental resources. Their approach is directed first towards increasing the understanding of how the various environmental systems function, second, to increasing the ability of decision makers to predict their interrelationships, and third, to improving the ability to control them. The methods emphasize the identification of basic data categories, and, through various computer-using methods, the aggregation of these into analyses which can demonstrate the constraints and opportunities of development decisions. They stress precision and validity of data, and the specification of measures of land capability. Examples of applications of the methods described are presented.

The two approaches alone do not relate exclusively to public lands. However, there are specific characteristics in the implementation of methods and policies of land and resource use which distinguish the public lands. Issues related to the planning processes of decision making and implementation are discussed in Environmental Quality and The Public Lands, while those concerning organization for the collection and control of resource information and analysis are discussed in A General System for Environmental Resource Analysis.

These reports present opportunities for improved decision making, and their application to the public lands are seen as critical to the establishment of a public environment of high quality.

Philip H. Lewis, Jr.
Madison, Wisconsin

Carl Steinitz
Cambridge, Massachusetts

January, 1970

ACKNOWLEDGEMENTS

The principle authors of this report are Carl Steinitz and David Sinton, and Allan Schmidt, consultant. Major contributions have been made by Douglas Way, Peter Rogers, and Timothy Murray.

Linda Peacock coordinated the report production, assisted by Rosalie Alexander, Robert Clapper, Vicki Erickson, Gary Gumz, Stephanie Hanks, Suzanne Kremer, Regina McDonald, Harry McDonnel, Tricia McManus, Nan Sinton, Ingrid Skalicky, Eve Valentine, and Candace Williams.

Steinitz Rogers Associates Inc.
Cambridge, Massachusetts
January, 1970

TABLE OF CONTENTS

Section B.

CHAPTER PAGE

FOREWORD i

ACKNOWLEDGEMENTS iii

LIST OF FIGURES vii

LIST OF TABLES xii

I. INTRODUCTION 1
- A. Some Fundamental Assumptions 1
- B. Current Resource Analysis Methods 4
- C. General Issues in Environmental Resource Analysis 9

II. DATA ACQUISITION 10
- A. Some Past Experiences 10
- B. Some General Issues 11
- C. Alternative Existing Data Sources 12
  - 1. Local Agencies 12
  - 2. Field Surveys 12
  - 3. Geophysical Surveys 12
  - 4. The U.S. Geological Survey 13
  - 5. Soil Conservation Service 13
  - 6. Other Governmental Agencies 13
- D. Alternative Data Sensing Methods 14
  - 1. Panchromatic (black and white) Aerial Photography 14
  - 2. Photographic Mosaics (black and white) 14
  - 3. Infrared (black and white) Photography 15
  - 4. Color (normal) Photography 15
  - 5. Color (infrared) Photography 15
  - 6. Ultraviolet Imagery 15
  - 7. Infrared Imagery or "Thermal Sensing" 16
  - 8. Radar Imagery 16
  - 9. Electromagnetic Imagery 16
  - 10. Multispectral Photography 17
- E. Summary Tables
- F. Data in Demand Factors 23

III. DATA CATEGORIES 24
- A. Zone Sets and Classification 24
- B. The Selection of Data Variables 26
- C. Sealing 32
- D. Categorization 32

IV. SPATIAL DESCRIPTION 34
- A. Defining the Study Area 34
  - 1. Political Borders 34
  - 2. Property Line Borders 34
  - 3. Watershed Borders 35
  - 4. Demand Area Borders 35
  - 5. Some General Issues 35

B. Geocoding 36
    1. Referencing 36
    2. Data Manipulation 36
    3. Geocoding Metrics and Referencing 37
C. Spatial types 40
    1. Types of Spatial Data 40
D. Zones for Data Grouping 41
    1. Single Predefined Zones 41
    2. Natural Resource Defined Zones 42
    3. Single All-Purpose Zones 42
E. Spatial Accuracy 43
F. The Grid as the Basis for Data Handling 44
    1. Grid Cell Size 44
    2. Two Alternative Procedures 47

V. METHODS OF RESOURCE ANALYSIS 49
A. General Goals 49
B. Description 50
C. Static Analyses 51
    1. Static, Single Factor Analyses 51
    2. Static, Multiple Factor Analyses 51
D. Dynamic Analyses 54
    1. Systems Analysis Models 54
    2. Types of Models 55
    3. Single-Sector Models 58
    4. Multiple Sector Models 60

VI. TECHNOLOGY: THE USE OF COMPUTERS IN ENVIRONMENTAL RESOURCE ANALYSIS 73
A. Introduction 73
    1. The Man in the Field 73
    2. Hand Drawn Maps 73
    3. Computers 74
B. Data Input 75
    1. Preparation of Data in Machine Readable Form 75
    2. Recording and Keypunching 75
    3. The Medium of Storage 76
    4. Long-Term Preservation of Data 77
C. Data Storage 78
    1. Definition 78
    2. Types of Data Files 78
    3. Two Alternative Data File Structures 79
    4. Grid Data Files 81
D. Data Processing 82
    1. Recording 82
    2. Classifying 82
    3. Sorting 82
    4. Calculating 83
    5. Summarizing 83
    6. Communicating 83
E. Output - Computer Graphics 84
    1. Criteria for Using Computer Graphics 84
    2. Output Hardware 85
    3. Software 87
    4. GRID 89

F. The Grid Program 89
G. Computer Graphics 92

VII. CONSIDERATIONS FOR MANAGEMENT 110
A. Management Issues in Organization 110
1. Centralization vs. Decentralization 110
2. Participating Agencies 113
B. Management Issues in System Design 115
1. Previous Problems 115
2. System Goals 116
3. Some Important Questions 117
C. Required Resources 118
1. Data 118
2. Computer Hardware 118
3. Computer Software 118
4. Computer Personnel 119
D. Pilot Studies 119

VIII. CONCLUSIONS 121

BIBLIOGRAPHY 122

APPENDIX A A.1

APPENDIX B B.1

LIST OF FIGURES

FIGURE NUMBER		PAGE
IV.1	The Least Common Denominator	46
V.1	Boston Region: Southwest Sector Regional Context	61
V.2	The Simulation System	63
V.3	Attractiveness for High Income Housing	65
V.4	Attractiveness for Medium Income Housing	66
V.5	Attractiveness for Low Income Housing	67
V.6	Attractiveness for Town Recreation	68
V.7	Attractiveness for Regional Recreation	69
V.8	Attractiveness for Natural Open Space	70
V.9	Visual Absorption	71
VI.1	GRID	93
VI.2	GRID	94
VI.3	GRID with INDEX	95
VI.4	Recreational Potential of Sub-Watersheds in the Charles River Basin	96
VI.5	Forest Density	97
VI.6	Onandaga and Cortland Counties Dominant Land Use	98
VI.7	Topographic Slope	99
VI.8	GRID with VIEWS	100
VI.9	Drainage Patterns of the Charles River Basin	101
VI.10	Residential Density TELEGRID	102
VI.11	Scotland, Acres of Tillage per 100 Acres of Agricultural Land	103

FIGURE NUMBER PAGE

VI.12 Average Two-Way Daily Traffic Flow 104

VI.13 Proposed Reservoir at Honey Hill 105

VI.14 OBLIX with GRID Data Systems 106

VI.15A OTOTROL with GRID Data System 107

VI.15B OTOTROL with GRID Data System 108

VI.15C OTOTROL with GRID Data System 108

VI.15D OTOTROL with GRID Data System 109

VI.15E OTOTROL with GRID Data System 109

VII.1 The Dimension of Management 114

A.1.1 Boston Urban Core Open Space and Building Height A.2

A.2.1 Exurban Development Study Land Suitable for Recreational Development A.4

A.3.1 Boston: Metropolitan Core Open Space and Recreation Maintenance Qualities A.6

A.4.1 New York State Population Density by Minor Civil Divisions A.8

A.4.2 Cortland and Onandaga Counties Active Agricultural Land A.9

A.5.1 Highway Corridor Selection Study A.11

A.6.1 DELMARVA Areas for Conservancy A.13

B.1 Boston Region: Southeast Sector Regional Context B.2

B.2 Boston Region: Southeast Sector Topography - Centroid Elevation B.8

B.3 Boston Region: Southeast Sector Topography - % Area 0-3% Slope B.9

FIGURE NUMBER		PAGE
B.4	Boston Region: Southeast Sector Topography - % Area 15%+ Slope	B.10
B.5	Boston Region: Southeast Sector Landform - Predominant Type	B.11
B.6	Boston Region: Southeast Sector Soil Type	B.12
B.7	Boston Region: Southeast Sector Water - % Area Wetlands	B.13
B.8	Boston Region: Southeast Sector Water - Predominant Type	B.14
B.9	Boston Region: Southeast Sector Forest - % Area Deciduous	B.15
B.10	Boston Region: Southeast Sector Forest - % Area Coniferous	B.16
B.11	Boston Region: Southeast Sector Forest - Predominant Density	B.17
B.12	Boston Region: Southeast Sector Agriculture - % Area in Active Agriculture	B.18
B.13	Boston Region: Southeast Sector Developed Land - % of Area	B.19
B.14	Boston Region: Southeast Sector Residential - Predominant Density	B.20
B.15	Boston Region: Southeast Sector Residential - Predominant Age of Development	B.21
B.16	Boston Region: Southeast Sector Residential - Predominant Maintenance Quality	B.22
B.17	Boston Region: Southeast Sector Public and Semi-Public Land - Predominant Type	B.23
B.18	Boston Region: Southeast Sector Recreation - Predominant Type	B.24
B.19	Boston Region: Southeast Sector Transportation - Air and Rail, Major Type	B.25

FIGURE NUMBER PAGE

B.20 Boston Region: Southeast Sector Transportation - Road, Major Type B.26

B.21 Boston Region: Southeast Sector Transportation - Distance to Projected Limited Access Highway B.27

B.22 Boston Region: Southeast Sector Environmental Nuisances - Predominant Type B.28

B.23 Boston Region: Southeast Sector Zoning - Predominant Type B.29

B.24 Boston Region: Southeast Sector Suitability for High Income Housing B.30

B.25 Boston Region: Southeast Sector Suitability for Medium Income Housing B.31

B.26 Boston Region: Southeast Sector Suitability for Low Income Housing B.32

B.27 Boston Region: Southeast Sector Site Construction Costs for Industry B.33

B.28 Boston Region: Southeast Sector Access and Town Costs for Industry B.34

B.29 Boston Region: Southeast Sector Composite Cost Map for Industry B.35

B.30 Boston Region: Southeast Sector Suitability for Regional Commercial Centers B.36

B.31 Boston Region: Southeast Sector Suitability for Hospitals B.37

B.32 Boston Region: Southeast Sector Suitability for Community Colleges B.38

B.33 Boston Region: Southeast Sector Suitability for Mass Transit Interchange B.39

B.34 Boston Region: Southeast Sector Suitability for a Regional Airport Based on Physical Factors B.40

B.35 Boston Region: Southeast Sector Suitability for a Regional Airport Based on Social Factors B.41

FIGURE NUMBER		PAGE
B.36	Boston Region: Southeast Sector Suitability for Commercial Recreation	B.42
B.37	Boston Region: Southeast Sector Attractiveness for Land Trails	B.43
B.38	Boston Region: Southeast Sector Attractiveness for Camping Sites	B.44
B.39	Boston Region: Southeast Sector Attractiveness for Water Trails	B.45
B.40	Boston Region: Southeast Sector Composite of Attractiveness for Outdoor Recreation Activities	B.46
B.41	Boston Region: Southeast Sector Suitability for a State Park	B.47
B.42	Boston Region: Southeast Sector Attractiveness for Conservation	B.48
B.43	Boston Region: Southeast Sector Attractiveness of Forests for Conservation	B.49
B.44	Boston Region: Southeast Sector Potential Wildlife Habitat	B.50
B.45	Boston Region: Southeast Sector Ecological Stability	B.51
B.46	Boston Region: Southeast Sector Ecological Stability	B.52
B.47	Boston Region: Southeast Sector Pressure on Wetlands for Filling	B.53
B.48	Boston Region: Southeast Sector Vulnerability to Septic Tank Pollution	B.54
B.49	Boston Region: Southeast Sector Relative Storm Water Run-Off in a Heavy Rain	B.55
B.50	Boston Region: Southeast Sector Potential Damage to Watershed by Change	B.56
B.51	Boston Region: Southeast Sector Impact of Ocean on Shoreline	B.57
B.52	Boston Region: Southeast Sector Susceptibility to Hurricane Damage	B.58

LIST OF TABLES

TABLE NUMBER		PAGE
I.1	Classification of Selected Resource Analysis Methods	5
II.1	Applications of Data Acquisition Techniques and Sources	18
II.2	The Relative Effectiveness of Data Sources for Variables Typically Encountered in Land Planning Data Inventories	19
III.1	Frequency of Use of Variables	27
V.1	Classification of Models	56

CHAPTER I

INTRODUCTION

Our work has been directed toward improving environmental planning. We have been developing methods in two of the principle components of any planning model: data inventory systems and analysis models. These have been applied to a variety of problem types and in a range of scales of area and detail, all of which are relevant to the use and management of public land resources. However, it is clear that the issues raised in this report are germane to all environmental planning and not solely those problem areas which, often by accident, are under the purview of the Public Land Law Review Commission.

Our presentation is therefore directed to the broader issues in environmental resource analysis for land planning, and our methods must be considered in a somewhat abstract manner. Many still theoretical issues must be discussed, but, as it has been said, "Nothing is so practical as a good theory."

A. Some Fundamental Assumptions

Our methods are based upon one fundamental concept, from which several subsidiary ideas are developed:

> More effective land use planning will be a result of more precise and efficient inventory and analysis methods.

In order to accomplish these:

1. It will be necessary to develop comprehensive data inventories and information management systems.

Criteria for data systems have been discussed by many others. Among them are:

- a. clearly defined, unambiguous and mutually exclusive categories;
- b. the inclusion of all relevant variables;
- c. applicability throughout the area of interest;
- d. applicability for all necessary analysis techniques;
- e. applicability at larger and smaller scales;
- f. the ability to generalize value scales;
- g. the capacity for being updated;
- h. accommodation of the interests of a broad range of anticipated users within the

availability of the primary sources of information;
i. the ability to be added to in both area and variables; and
j. an orderly, compact, and economical format.

2. The inventory and analysis system must be oriented to computer use.

Planners and decision-makers in all fields are recognizing that computers, once their benefits and limitations are understood, are the most powerful tools in the data handling, analysis, and display functions which are normally part of environmental resource analysis. It seems clear to us that the use of computers in this field will increase rapidly in the near future as various agencies begin to consider establishing resource data banks. The questions will then be, "How will these data be organized?" and, "How will they be used?" Furthermore, the rapidly increasing availability of computers and the even more pronounced decreases in their operational costs make computer use increasingly attractive, in efficiency (measured in terms of time, manpower, and money) and in their ability to perform an increasingly wide variety of programmed analytic techniques. Some of these can be efficiently accomplished only by computer.

Computers and computer programs are capable of handling the analysis of a great deal of data but can do so only within extremely precise limits prescribed by the characteristics of the data, the manner in which they are stored, and the capabilities of the computer and the computer programs which are available for use. The user must specify not only what he will want, but he must also specify precisely how he proposes to go about performing the necessary operations on the computer. This need for explicitness implies at the least the need for a consistent and well-disciplined analytic approach. Thus, while computers will not and cannot replace human understanding, they can certainly help to focus and manage the enormous effort involved in environmental decision making.

3. Since the ultimate purposes to which environmental information systems are to be put are not totally definable, it will be necessary to provide a general system, within which each user can be technically served, subject to the cost and reliability constraints of the system as a whole.

It is therefore necessary to understand the "state of the art" of resource analysis, since what is done now will have to be continued until replaced by alternative and, hopefully, improved methods.

4. Improved theory and predictive analysis methods, are necessary to any field, and particularly to the complexities of environmental planning.

Given increasing public awareness of the need for resource use policies which will minimize the inevitable conflicts among the various demands for land, resource analysts and planners are challenged to go beyond the level of individuality and towards a level of understanding which approaches the theoretical. It is absolutely critical that the various individuals and disciplines whose knowledge and experiences offer insight into the many issues involved in resource use be able to work together. The language of this interaction among scientists, planners, policy makers and consumers may well be that of a computer system. It must be presumed that this interaction will lead to the development of more powerful and effective analytic and planning methods. These methods must be directed first to increasing the understanding of how the various environmental systems function, second to increasing the ability of decision-makers to predict their operation, and third to improving their ability to control them.

B. Current Resource Analysis Methods

A summary is presented in this section of selected resource analysis studies by the following individuals and groups. The summary is derived from a study by Steinitz, Murray, Sinton and Way (101.23) in which selected resource analysis projects of the following individuals and groups were described:

1. Richard Allison and Roger Leighton
2. Chester County Planning Commission
3. C.S. Christian
4. John A. Dearinger
5. G. Angus Hills
6. Philip H. Lewis, Jr.
7. R. Burton Litton, Jr.
8. Ian L. McHarg
9. PARIS: The State of California
10. RECSYS: The State of Michigan
11. Soil Conservation Service: 1
12. Soil Conservation Service: 2
13. Richard E. Toth
14. U.S. Army Corps of Engineers
15. Edward A. Williams
16. Research Planning and Design Associates
17. C. Steinitz, P. Rogers, and Associates

For a more detailed description on the selected approaches, including: their methodological goals; the constraints under which the method was developed or under which it operates; the data variables which are investigated; the logic of the analytic approach; the applicability of the method to other areas, scales, and purposes; and its principal documentation; see the cited study and the sources in the bibliography of this report (89-104).

These approaches will be referred to often in this report, particularly in Chapter V on analysis methods. They represent the current state of the art in a fast changing field. In theory, a general system for environmental resource analysis should include the capabilities needed for these individuals and groups to be able to use it in their work.

These methods illustrate the major aspects of current resource analysis. In order of increasing complexity, these are: 1) land classification; 2) resource inventory; 3) resource-centered analysis, indicating where development changes should not occur; 4) analysis linked with demand, showing where change might or should take place; 5) single-sector models which predict the effects of change; and 6) multi-sector models in which several sectorial models can interact in a general planning system. One common method which we do not discuss is that of the "old timer" -- the expert who has extensive and intensive knowledge based upon long experience in a particular geographical area or with a type of resource. One cannot underestimate or fail to respect the power of this kind of expertise, but neither can one readily teach or transfer that method.

Table I.1 presents a summary classification of the selected resource analysis studies which are representative of the various analytic approaches currently in use.

The caveats which underly this survey must be made clear. It must be constantly remembered that each approach has different goals, data requirements, scales, political constraints, time and money budgets, expertise, etc., and any comparison makes many implicit assumptions about these most important variables.

One area in which it is not possible to make comparisons of these studies, and which perhaps is one of the most crucial, is that of cost and efficiency. For a variety of reasons, most of which are obvious, the time, dollar, and manpower costs of resource analysis studies are never stated in their documentation. These surely must vary greatly. While one hesitates to apply criteria of cost effectiveness to the obvious "good" of natural resource evaluation, it is nonetheless an important factor to be considered, particularly by the public or private client.

TABLE 1.1 CLASSIFICATION OF SELECTED RESOURCE ANALYSIS STUDIES

DATE	STUDY TITLE BIBLIO. CIT.	NAME
c. 1967	Evaluating Forest Campground Sites (89)	Alli-.-Lei.
1963	Natural Environment and Planning (90)	Chester Co.
1968	Aerial Surveys and Integrated Studies (91.1)	Christian
1968	...Recr. Potential...Streams...Urban Areas (92)	Dearinger
1960	Glackmeyer Report (93.7)	Hills
1967	Upper Mississippi Comp. Basin Study (94.1)	Lewis
1963	Landscape Analysis 1: Lake Superior S. Shore (94.7)	Lewis
1968	Forest Landscape, Description and Inv. (95)	Litton
1969	Staten Island Study, in: Design with Nature (96.1)	McHarg
1963	Plan for the Valleys (96.8)	McHarg
1966	Park and Recreation Info. System (PARIS) (97.5)	PARIS
1966	Mich. Outdoor Recreation Demand Study, Report 6, (98.3)	RECSYS
1960	Soil Survey, Indiana County, Penn. (99.1)	SCS:1
1966	...Potentials for Outdoor Recreation Dev. (100)	SCS:2
1968	...Valuable Natural Resources...TIRAC (102.1)	Toth
	Resource Inventory, Costa Rica	Corps Eng.
1969	Open Space, Choices Before California (103)	Williams
1967	...Visual and Cultural Envir., (prelim.) (104.3)	Res. Pl. & Des.
1968	Urbanization and Change (101.19)	Steinitz Rogers

(TABLE I.1 cont'd.)

SPONSOR	STUDY AREA	SIZE	
N.H. Dept. of Nat. Res. Univ. N.H.	Potential Campgrounds	n.a.	Alli.-Lei.
County Govt.	Chester Co., Penn.	600 sq. mi. ±	Chester Co.
State Govts.	Large Regions, Australia	100,000 sq. mi. ±	Christian
U.S. Dept. of Interior Univ. Ky.	Lexington, Ky. Region	100 sq. mi. ±	Dearinger
Ontario Dept. of Lands and Forests	Large Regions, Canada	3,000 sq. mi. ±	Hills
Nat'l. Park Services U.S Dept. of Interior, etc.	Multi-State Region	300,000 sq. mi. ±	Lewis
Wisc. Dept of Resource Dev.	County, Wisconsin	5,000 sq. mi. ±	Lewis
Forest Service, U.S. Dept. of Agric.; Univ. of Calif., Berk.	Highway Corridors	20 mi. ±	Litton
Dept. of Parks, City of N.Y.	Staten Island, N.Y. City	100 sq. mi. ±	McHarg
G.S.W. Valley Plan. Council (Local Citizen Group)	Baltimore Suburban Fringe	100 sq. mi. ±	McHarg
Calif. Dept. of Parks and Rec.	Calif. Metropolitan Regions	150,000 sq. mi. ±	PARIS
Mich Dept. of Commerce, Mich. State Univ.	Mich, State Parks	60,000 sq. mi. ±	RECSYS
U.S. Dept. of Agric.	County (all U.S.A.)	1,000 sq. mi. ±	SCS:1
U.S. Dept. of Agric.	Potential Recr. Areas	n.a.	SCS:2
Tocks Island Reg. Advis. Council	Townships, Penn.	1,000 sq. mi. ±	Toth
Eng. Resources Inv. Center	National, Regional	20,000 sq. mi. ±	Corps. of Eng.
Calif. State Office of Plan.	Calif. Metropolitan Regions	10,000 sq. mi. ±	Williams
N. Atlantic Reg. Water Resources Study, Coord. Comm.	Multi-State Region	150,000 sq. mi. ±	Res. Pl. & Des.
Dept. of L. Arch., Harv. Univ.	Boston Region, S.W.	400 sq. mi. ±	Steinitz Rogers

(TABLE I.1 cont'd.)

		Alli.-Lei.	Chester Co.	Christian	Dearinger	Hills	Lewis	Lewis	Litton	McHarg	McHarg	**PARIS**	RECSYS	SCS:1	SCS:2	Toth	Corps. of Eng.	Williams	Res. Pl. & Des.	Steinitz Rogers
SUBJECT	Urban		X	X			X			X	X			X		X	X	X		X
	Agric.		X	X		X	X				X			X			X			
	Forest		X	X		X	X				X			X			X			
	Recr.	X			X	X	X	X		X	X	X	X	X	X	X		X		X
	Conserv.					X	X	X		X	X			X		X		X	X	X
	Visual				X		X	X	X	X	X								X	X
DATA SOURCES AND ZONES	Resource Based	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Politic. Based			X	X							X	X			X	X	X	X	X
	Other Incl. Grid	X							X			X								X
	Avail. Publ. Data	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Special Data Col.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Air Photo			X		X								X			X			X
	Field Survey		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

(TABLE I.1 cont'd.)

		Alli.-Lei.	Chester Co.	Christian	Dearinger	Hills	Lewis	Lewis	Litton	McHarg	McHarg	PARIS	RECSYS	SCS:1	SCS:2	Toth	Corps. of Eng.	Williams	Res. Pl. & Des.	
ANALYTIC METHOD	Descript. Classif.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Supply Attract.	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X
	Supply Constrnt.	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X
	Non-Prof. Eval.						X	X						X	X			X		X
	Expert Eval.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Numer. Point Rat.	X			X		X	X					X		X			X		
	Analytic Der. Eval.				X								X							X
	Consumer Survey				X								X							X
	Demand Analysis	X			X	X					X	X	X					X		X
	Analytic Model											X	X							X
	Predict. Model						X				X	X	X		X	X				X
	Simul. Model				X								X							X
	Plan Proposal			X	X	X		X		X	X			X		X		X	X	
	Impliment Strategy										X							X		
	Computer Use				X							X	X					X		X

C. General Issues in Environmental Resource Analysis

The survey was directed towards defining criteria for a more comprehensive approach to resource analysis. There are several important issues which are generic to all environmental resource analysis, and these will be necessary components of any general approach to land planning. They should be explicitly considered in the design of any planning study. Among these issues are:

1. The availability of sources and methods for data acquisition (see Chapter II).
2. The classification and selection of data variables (see Chapter III).
3. The system of geographic referencing and the spatial description of data (see Chapter IV).
4. The variety of available and potential analysis methods (see Chapter V).
5. The technology of data handling: manual vs. computer methods (see Chapter VI).
6. The management of resource analysis (see Chapter VII).

Within each of these issues there are many alternatives among which choices must be made. None of these can be made in the abstract, or independently from each other. They are all largely determined by an interaction between the requirements of the analytic uses to which data are to be put and the several costs of data acquisition and analysis.

CHAPTER II

DATA ACQUISITION

To initiate any particular planning process a primary concern involves data definition and data acquisition. The specific data needed for each project will obviously vary depending upon the planning issues, site size and location, budget, schedule, accuracy, and analytic flexibility required. Data inventory is a costly process and stringent organization is needed to provide the complex range of data to be manipulated later within the planning process.

This section attempts to briefly discuss the range of data sources which are presently or potentially available to the land planning professions to aid in the data inventory stage. Each data source and sensor is briefly presented, stating the particular efficiencies that it offers. Two tables are presented to provide a basic understanding of the sources and sensors which best provide typical predefined categories of data. The discussion does not attempt to evaluate relative merits of using one sensor over another because of the complexity of the specific issues involve. The study is primarily aimed at describing alternative techniques or combinations that can provide the accurate, current, and relevant data required for a specific inventory.

A. Some Past Experiences

Considering the variety of purposes and scales of interest of resource analysis methods, one notes a substantial consistency in the sources from which data are derived. Basically, one suspects that the general rule is "Use the best data that you can get." Most existing resource methods rely on data which are commonly available in published sources, such as general climatic information, topographic data, surface water and vegetation data, and basic land uses. In most cases these data sources are those publicly available documents provided by the government, notably the USGS maps and the Soil Conservation Service maps, and several methods clearly make use of these maps in creating overlays which they then combine in their various analyses. The studies that investigate demand as part of their analytic method typically make use of statistical data summarized in the U. S. Census.

On the other hand, several of the existing methods, notably those for large undeveloped areas [Hills (93), and Christian, (91)], recognize that it may be more efficient in terms of time, money, and manpower to collect data "from scratch", rather than to collect, collate, and reorganize the existing, often scanty or erroneous, data on a region. Typically these methods turn to some form of aerial photographic analysis.

A substantial portion of a resource data bank can be easily derived through air photo interpretation. Both photo recognition and interpretation are used to obtain data. Recognition is basically an instantaneous visual identification, whereas interpretation involves more complex inferential processes in order to identify data types.

Several of the methods demand personal field investigation by the group making the evaluations: the Allison and Leighton (89) and the Soil Conservation Service campsite analysis methods (100), and the evaluation of the resources of State Parks in the Michigan RECSYS study (98) are examples. Several of the resource methods decentralize this process. Lewis (94) makes use of local experts, county agents, etc., to identify the extrinsic and intrinsic resources upon which he bases several of his evaluations. The Soil Conservation Service also has methods aimed at helping local groups to evaluate their own resources (99, 100).

In summary, analyses are largely governed by the data available, and often the question asked by the resource analyst is "Given the data available, how can we evaluate for ____?" But analysis must not be biased by the availability of data. Just because one has data does not necessarily mean that one needs to use it. However, if data are not available, this does not necessarily mean that analysis must be terminated.

B. Some General Issues

There are many general problems that must be defined when discussing alternative data sources. The individual requirements of each job will dictate to a large extent the cost limitations on data acquisition. If little money is available for an inventory, limitations on the accuracy of acquired data must be understood and accepted. In addition, accurate data sources themselves will not provide relevant and accurate information unless they are interpreted and recorded on a professional level of confidence, e.g., an individual who has never utilized air photo interpretation principles would not be able to accurately map soil and rock conditions from air photos. Each data source and sensor examined must be accompanied by the professional expertise to manipulate it accurately for the desired information.

It is also important to realize that in gathering any data, a system of cross-checking must be maintained to provide an accuracy measure. One of the best techniques is to utilize several data sources or sensors to provide information rather than just one. While budget and schedule may severely limit the number of sources and sensors to be used, field checking should always be incorporated as a minimum control.

Each data source also has its inherent problems of accuracy and resolution. Panchromatic black & white photos as illustrated by RAND Corporation (77) can delineate 6-inch parking strips when taken at 100,000 feet. According to a study done at Raytheon (77), Airborne Radar (SLAR) can distinguish 50 foot objects and is suitable for 1:250,000 scale mapping. However, electromagnetic (long wavelength) sensors struggle for any recognizable resolution. These problems of cost/accuracy/resolution will be solved over time and will be applicable to a wider range of data categories in the future.

The actual feasibility of utilizing many of the more sophisticated sensors has not yet been proven. Many of these items are still very expensive and are not readily available to the general professional public (e.g. such items are electromagnetic sensing, infrared imagery, some radar equipment, etc.). However, in future years many of these more sophisticated sensors will be incorporated in earth resource survey sensing satellites providing data that could be utilized by planning agencies. As this type of data is likely to become available it has been included in this discussion.

C. Alternative Existing Data Sources

1. Local Agencies

Depending upon the site location large amounts of existing data may be available from local, state, or governmental agencie. In most instances these data are available and free as a public service. Local data should always be investigated before any authorizations are given to procure new surveys. The amount, type, etc. of existing data will actually determine the scope of new surveys and needed photography.

2. Field Surveys

Though more expensive per square mile, field surveys are usually the most accurate process of gathering data. They are used most efficiently in conjunction with other data sources and sensors, primarily to verify their interpretation and accuracy. Field surveys should always be a part of even the most sophisticated data gathering system in order to provide verification of accuracy limits. These surveys can often be conducted in cooperation with the Soil Conservation Service or other county or local agencies that are familiar with the study area.

3. Geophysical Surveys

To obtain specific engineering information, selected field survey methods must be incorporated. Geophysical and auger surveys in conjunction with laboratory tests provide definitive data upon which structural engineering decisions can be made. This type of data is generally available from engineering consulting firms but is not utilized until specific sites have been selected. This type of data acquisition represents the finest, most specific scale of data gathered relating to physical conditions.

4. The U.S. Geological Survey

The U.S. Geological Survey has been providing, since 1882, general purpose maps of appropriate scale and accuracy for all of the country. Many series and scales are presented to satisfy the wide range of user demands. The two map series most widely used by planners are 1:24,000 scale (2000 ft./inch) and 1:62,500 scale (5280 ft./inch) quadrangle maps. Mapping of geologic features has been completed for the whole United States at a general scale of 1:5,000,000. The map series of 1:250,000 scale (4 miles/inch) are sometimes utilized for large scale studies. All these maps are available from the Map Information Office in Washington, D.C. for nominal cost. Available geologic coverage for the U.S. can also be obtained in index form from the Map Information Office, Washington, D.C.

5. Soil Conservation Service

The Soil Conservation Service of the U.S. Department of Agriculture has been making and publishing soil surveys since 1899. These surveys are intended to provide information on soils to the general public. These are available free of charge from the Information Division, Soil Conservation Service, Washington, D.C., to those land users or professionals who require the information. Only one-third of the United States has been mapped at this time, with the most relevant maps for planners completed after 1957. The SCS does not project the completion of mapping until after the year 2,000. A list of mapped counties can be obtained from the SCS in Washington.

The Soil Conservation Service county agents are of great value in compiling a data inventory. A local individual working in the field twenty or more years can certainly be valuable in field checking, measuring accuracy, or obtaining raw data. This is especially true for dynamic data categories such as ecology and wildlife.

6. Other Governmental Agencies

Depending upon the site location, other agencies with responsibilities for land areas may be of assistance. Included are the Department of Commerce, Forest Service, Bureau of Out-Door Recreation, National Park Service, Department of Wildlife and Fisheries, etc. Usually the central office of each agency in Washington, D.C. would know the specific data available for a particular region or would direct the caller to the relevant field office.

D. Alternative Data Sensing Methods

1. Panchromatic (Black and White) Aerial Photography

All of the United States and its territories have been photographed in black and white photographic coverage by governmental or commercial organizations. Most of this photography is flown at 1:20,000 or 1667 ft./inch and provides sufficient detail for land use pattern recognition, landform identification and soils mapping. Agencies having aerial photographic coverage include the Agriculture Stabilization Conservation Service, Soil Conservation Service, Forest Service, Geologic Survey, and Coast and Geodetic Survey. Indexes showing the coverage of each agency can usually be obtained from the Washington, D.C. offices.

Panchromatic photography and interpretation techniques have been utilized in the past for a wide range of data acquisition. Crop patterns, trees, wildlife species and range, geology, geomorphology, soils, geography, hydrology, oceanography, etc. are a few of the data categories that can be interpreted from information derived from panchromatic photos. Many interpretation techniques from black and white photos are possible, but because of the complexities of the subject it cannot be covered here. The authors suggest "The Manual of Photographic Interpretation" (59) of the American Society of Photogrammetry which gives a comprehensive background of panchromatic interpretation techniques and applications. Such photography at this point in time yields the most accurate information of any sensor concerning the size, shape, and relative positions of objects and patterns.

2. Photographic Mosaics (Black and White)

Black and white photomosaics are generally available for any particular study area. These can be obtained from the same particular agency that has the aerial coverage. Photomosaics are generally small scale (typically 5280 ft./in.) and do not offer a 3-dimensional or stereo image, thus limiting their range of application. Major landform groups, drainage patterns, urbanization, forests, broad agriculture, etc. can be generally determined. Mosaics are very inexpensive and would prove of value when studying very large areas. The mosaic can generally offer enough information to establish which areas within them justify further detailed study.

3. Infrared (Black and White) Photography

Infrared film captures the upper end or near infrared portion of the spectrum that is not normally visually apparent. Solar energy reflecting from a broad-leafed plant will reflect visible energies differently from infrared energy. Thus, vegetation inventories and soil analyses can be greatly aided by black and white infrared photographs.

4. Color (Normal) Photography

Color aerial photography has recently become relatively inexpensive. Printing costs, however, are still high, and suitable flying weather is a problem in some areas. However, it has been proven that color aerial photography gives the best overall coverage of any sensor technique available. Qualified interpretors can extract reliable data in greater amounts and more rapidly from color than they can from regular panchromatic black and white photos or from black and white infrared. It is probably most efficient at 1:48,000 or 400 ft./inch where detailed physical information (vegetation, land use, and soils) can be extracted.

5. Color (Infrared) Photography

Color infrared has the wide tonal and hue advantage of color in addition to the specialized properties of the infrared spectrum discussed under black and white infrared photography. Healthy vegetation, being a high reflector of infrared radiations, is recorded with a brilliant red or pink color, indicating the condition of the spongy mesophyll in the leaf structure. Crop and tree diseases, blights, fungi, etc. can readily be identified on the color infrared. Color infrared also shows detailed changes in soil moisture conditions and vegetation cover types and density. Soil mapping is more efficient and accurate if infrared color is utilized.

Color infrared is best applied when interpreted with true color aerial film and panchromatic black and white. Color and tonal shifts can then be studied in more detail to provide a system of cross-checking when identifying and measuring data variables.

6. Ultraviolet Imagery

Ultraviolet sensing is virtually unavailable commercially, but experiments show promising applications in providing geologic and oceanographic information. The technique senses element vapors such as mercury and iodine, capitalizing on the fact that most of the atomic absorption lines in the spectrum are contained within the ultraviolet range. At this time, and for most applications and data needed by land planners, ultraviolet sensors are not feasible.

7. Infrared Imagery or "Thermal Sensing"

Infrared imagery has already proven to be of great value in certain specific data acquisition projects. It detects and constructs a photographic-like image showing variation in the emitted thermal infrared radiation of objects. The resulting image will show warmer objects as light tones and cold objects as dark ones. Some specific problems of thermal activity are almost completely dependent upon this sensor for data. These sensors are being used by the U.S. Forest Service to detect and map forest fires and locate hot spots even through thick clouds of smoke (77). Ecologists are using this sensor to map thermal differences in rivers caused by power plant heat pollution, volcanic activity in Hawaii, geothermal activity in Yellowstone Park, and detection of crevasse snow bridges. Unfortunately, availability of this sensor is still somewhat limited for use in land planning.

8. Radar Imagery

Radar imagery has proven to have wide large-scale data acquisition capabilities. Side Looking Airborne Radar (SLAR) can continuously map large areas, reconstructing a photographic-like image from the reflected component of a self-generated radio frequency pulse. Being a radio transmission, it can be done regardless of atmospheric conditions. Night mapping and penetration through clouds, ice, and certain vegetation cover can also be accomplished with this sensor. The image formed very clearly shows surface roughness, structural geologic conditions, general moisture differences, and slopes. A NASA-supported research team coordinated by the Center of Research in Engineering Science at the University of Kansas is investigating the total range of potential radar-data capabilities and applications (71). The primary potential is in mapping large undeveloped countries or regions that cannot afford to utilize panchromatic black and white aerial coverage. This sensor can be contracted for use through several commercial firms primarily concerned with its development.

9. Electromagnetic Imagery

Electromagnetic sensors are still in the early stages of development but already have some very specific data acquisition capabilities. The U.S. Army Electronic Laboratories (71) has directed a task force which has successfully, with low flying electromagnetic sensors, penetrated ice up to 9300 feet. With these devices, mapping of terrain surfaces can be done through continental ice sheets.

10. Multispectral Photography

Through multispectral photography, the tonal discrepancies of different objects can be compared within segmented portions of the spectrum providing an overall tonal signature pattern for each object. By this technique many geologic, vegetation, and crop patterns can be automatically identified by scanners once their tonal variances across the spectrum are defined. These sensors are still in early stages of investigation and require expensive specialized equipment. However, further refinement of integrated satellite-computer-scan-storage systems will rely heavily on multispectral properties using black and white, infrared, and color images exposed simultaneously.

E. Summary Tables

To help focus the specific applications of some of the sources and sensors, the following tables have been prepared showing, on a comparative basis, a range of possible data applications for different broad data categories. It must be remembered, however, that not all of the techniques listed are presently commercially available.

In Table II.1 the overlap of sensor techniques for each broad data category can be observed.

Table II.2 incorporates a specific list of data variables found to be used in various methods of land planning (101.22). Each data source and sensor is also listed and the effectiveness of each is indicated with a 0,1,2,3 ordinal ranking. This table indicates which of the sources are currently best for supplying information on specific variables and which sensors tend to be the most efficient within certain categories.

Table II.2 indicates that multispectral photographic methods offer the greatest range and potential for data acquisition. However, because of their expense, large area surveys to be commercially contracted would not be feasible unless incorporated into a government satellite sensing program.

Air photos also offer a wide range of information especially if a combination of types is used. If not, color photos as a single source hold the greatest values. The other sensors, ultraviolet, infrared imagery, and radar (SLAR) have rather specific data applications that

DATA GATHERING TECHNIQUE	AGRICULTURE	FORESTRY	GEOLOGY AND SOILS	HYDROLOGY	OCEANOGRAPHY	GEOGRAPHY
FIELD SURVEYS	Specific Crop Identification Identification of Crop Vigor	Specific Tree Type and Ecology General Health	Specific Rock Identification and Structural Soil type Composition and Characteristics	Flow Velocities and Volume Measurements Water Quality	Water Mineral Pollutant and Chemical Composition Depth Soundings and Turisidity	Specific Land Uses Individual Structure Identification Terrain and Veg Character
GEOPHYSICAL SURVEYS			Core Log Borings Auger Surveys Seamic Surveys Magnetic Measurements			Magnetometer Surveys Gravity Meters
U.S. GEOLOGICAL SURVEY (QUADRANGLE MAPS)	Vineyards Orchards Cranberry Bogs	Woodland Scrub Wooded Marsh	Glaciers Contours Dune Areas Sand Areas Large Washes Gravel Beaches Dry Lake Bed	Perennial Streams Springs Rapids Soundings Intermittent Streams Falls Inundated Areas Swamps	Coral Reef Rocks Foreshore Flat	Land Use Circulation Patterns Road, Rail, Air, Water Mineral Workings Structures, Buildings Bench Marks Boundaries
SOIL CONSERVATION SERVICE TECHNIQUE	Crop Production Estimates by Soil Type Erosion Problems	Woodland Management Problems by Soil Type	Soil Types Composition Characteristics Capabilities Eng. Properties	Capability of Soils for Impoundment Internal Drainage Erosion		Capability of Soils Potential Land use Development Including Utility Options
AERIAL PHOTOGRAPHY PANCHROMATIC (BLACK AND WHITE) STEREO	Crop Identification and Pattern	Vegetation Identification and Pattern Ecologic Assoc.	Identification of Surface Structure Landforms Topography General Soil Types and Characteristics	Drainage Patterns Inundated Areas Swamps Marshes Bogs Gullies	Sea State Off Shore Depth Beach Erosion and Deposition Turgidity	Urban and Rural Land Use Categories Circulation Patterns Residential, Comm Industrial, Terrain. Vegetation Characteristics
AERIAL PHOTOGRAPHY INFARED BLACK AND WHITE	Crop Identification and Pattern	Vegetation Identification Confers vs. Deciduous Ecologic Assoc.	Topography Surface Structure Landforms General Soil Types and Moisture Characteristics	Water Body Identification Drainage Patterns Soil Moisture	Coastal Shoreline Moisture Variences Water Systems along Shorelines Ice Type Mapping	General Land Use Patterns
AERIAL PHOTOGRAPHY COLOR STEREO	Crop Identification and Pattern	Vegetation Type Ecologic Association	Rock Types, Attitude Soil Types Composition and Characteristics Topography	Water Bodies Drainage Pattern Water Quality Turgidity	Water State Coastal Conditions Turisidity, Beach Erosion and Deposition Coral Reefs, Off Shore Depth	Detailed Urban & Land Use Categories, Detailed Overall Terrain, Vegetation Analysis
AERIAL PHOTOGRAPHY INFARED COLOR STEREO	Crop Identification and Health Disease Identification	Vegetation Pattern and Health Disease Identification	Soil Moisture and Composition Topography	Water Bodies and Condition Algae Gullies Drainage Pattern	Living Organisms Ice Identification Shoreline Moisture Conditions	Detail Urban and Land Use Categories Detailed Overall Terrain, Vegetation Analysis
PHOTOGRAPHIC MOSAICS	Crop-Agricultural Pattern	Forest Pattern	Broad Landform Groups	General Regional Drainage Pattern	Overall Shorelines Conditions Erosion and Deposition	General Categorical Identification of Agriculture, Urban Areas, Rural Areas, and Forested Areas
ULTRAVIOLET SENSORS			Mineral Location and Identification		Detection and Measurement of Surface Marine Flora	
INFARED IMAGERY OR THERMAL SENSORS	Crop Vigor and Disease Condition	Forest Fire Detection Vegetation Vigor and Disease Condition	Mapping of Thermal Volcanic and Geothermal Activity	Identification of Areas Cooled by Evaporation	Ocean Current Mapping and Sea Ice Identification	Land Use
RADAR (SIDE LOOKING AIRBOURNE RADAR) SLAR	Agriculture Pattern Soil Characteristics	General Soil Characteristics	Surface Roughness and Geologic Tectonic Mapping Regional Soil Units	Soil Moisture Content (General) Run off Slopes	Sea State Ice Identification and Thickness	Broad Patterns of Cultural Land Use
ELECTROMAGNETIC PULSE SENSORS			Measurement and Mapping of Subsurface layering (Beneath Ice)	Snow and Ice Surveys	Sea Ice and Ocean Current Mapping	Snow and Ice Measurements
MULTI-SPECTRAL TECHNIQUES	Crop Identification and Disease Patterns	Vegetation Identification and Disease Patterns	Soil Types and Composition Geologic Surface Conditions Landform	Soil Moisture Content Gullies Drainage Pattern	Sea Color Indicating Living Organisms	Urban and Rural Land Use Patterns Terrain and Veg Characteristics

TABLE II.1
APPLICATIONS OF DATA ACQUISITION TECHNIQUES AND SOURCES See (71).

TABLE II.2

THE RELATIVE EFFECTIVENESS OF DATA SOURCES FOR VARIABLES TYPICALLY ENCOUNTERED IN LAND PLANNING DATA INVENTORIES.

NATURAL RESOURCES	FIELD SURVEYS	GEOPHYSICAL SURVEYS	LOCAL OR OTHER GOVERNMENTAL SURVEYS	U.S. GEOLOGIC SURVEY	SOIL CONSERVATION SERVICE	AERIAL B&W PANCHROMATIC	AERIAL INFRARED B&W PHO.	AERIAL COLOR PHOTOGRAPHY	AERIAL INFRARED COLOR PHO.	PHOTOMOSAICS	ULTRAVIOLET SENSORS	INFRARED IMAGERY (THERMAL)	RADAR (SLAR) IMAGERY	ELECTROMAGNETIC IMAGERY	MULTISPECTRAL IMAGERY
CLIMATE															
RAIN			3												
SNOW			3									3		3	
TEMPERATURE	2		2												
RADIATION	1		2									2			
FOG	1		2												
WIND	1		3												
FROST	1		2									1			
STORMS			3										2		
AIR DRAINAGE	1		2												
GEOLOGY															
BEDROCK OUTCROPS	1	1	1	1	1	2	1	2	2	0			2		2
BEDROCK TYPE	3	3	3	2	2	2	1	2	2	1			3		2
UNIQUE FORMATIONS	3	3	3	3	3	2	1	2	2	1			3		2
STABLE FORMATIONS	3	3	3	3	3	2	1	2	2	1			3		2
DEPTH TO BEDROCK	3	3	1	1	3	2	1	2	2	1			0		2
BUILDING MATERIALS															
STRUCTURAL TYPE															
STRUCTURAL AGE	3	3	3	3	2	1	1	1	1	0			1		
WEATHERING TYPE															
VOLCANIC ACTIVITY	1	3	1	2	1							3			
ECONOMIC MINERALS	1	3	1	2	1	1	1	1	1	1	2		1		1
LANDFORMS-TYPE	2	2	1	2	2	3	2	3	2	1			2		3
UNIQUE FEATURES															
SOILS															
SOIL TYPE	3	3	1		3	2	2	3	2	1			1		3
SOIL TEXTURE	3	3	1		3	2	2	3	2	1			1		3
SOIL DEPTH	3	3	1		2	2	2	2	2	0			1		2
INTERNAL DRAINAGE	3	1	1		3	2	2	3	2	1					2
ERODABILITY	2	1	2		3	2	2	3	2						2
BEARING CAPACITY		3	2		3	1	1	1	1						1
PERMEABILITY	2	3	2		3	1	1	1	1						1
INSTABILITY	1	3	2		3	1	1	2	1						2
STONINESS	3	3	2		3	1	1	1	1						1
PRODUCTIVITY	1		2		3	1	1	1	1						1

NATURAL RESOURCES (CONTD)	FIELD SURVEYS	GEOPHYSICAL SURVEYS	LOCAL OR OTHER GOVERNMENTAL SURVEYS	U.S. GEOLOGIC SURVEY	SOIL CONSERVATION SERVICE	AERIAL B&W PANCHROMATIC	AERIAL INFRARED B&W PHO.	AERIAL COLOR PHOTOGRAPHY	AERIAL INFRARED COLOR PHO.	PHOTOMOSAICS	ULTRAVIOLET SENSORS	INFRARED IMAGERY (THERMAL)	RADAR (SLAR) IMAGERY	ELECTROMAGNETIC IMAGERY
TOPOGRAPHY														
ELEVATION	1		1	3		3	3	3	3					
EXCESSIVE TO UTILITIES														
RAVINES	2		1	2	1	3	3	3	3	1		1	1	
SLOPES	2		1	3	1	2	2	2	2				1	
RIM OF SLOPE	1			3		3	3	3	3				1	
RELIEF VARIATION	2			3		3	3	3	3			2	2	
ORIENTATION	1			3		3	3	3	3			3	2	
WATER														
WATERSHEDS	1	1	1	3	1	3	3	3	3	3		3	3	
DRAINAGE PATTERNS	1	1	1	3	1	3	3	3	3	3		3	3	
GROUND WATER	1	3	3	3	2	2	2	2	2	1		1	1	1
AQUIFERS	1	3	3	3	3	1	1	1	1	1		1	1	1
LAKES	3		3	3	3	3	3	3	3	3		3	3	
RIVERS-STREAMS	3		3	3	3	3	3	3	3	3		2	2	
WETLANDS	3		3	3	3	3	3	3	3	2		2	2	
SPRINGS	3	3	3	3	3	2	2	2	2	0		3	0	
WATERFALLS	3		3	3	3	2	2	2	2	0		1	0	
FLOODS (POTENTIAL)			3	1	1									
WATER QUANTITY	3	3	3	3		2	2	2	2	0		1	1	1
WATER QUALITY	3	3	3			2	2	2	2	0	1			
WATER TEMPERATURE	3	3	3									3		
DIS. & SUS. SOLIDS	3	3	3			2	2	2	2	0				
BIOLOGIC PRODUCTIVITY	3	3	3			1	1	1	1	0				
SHORELINE TYPE (USE)	3		2	1		2	2	3	2	1			1	
SHORELINE QUALITY	3		1			2	2	3	2	0				
VEGETATION														
VEGETATION TYPE	3		3		3	2	2	3	2	1		1		
VEGETATION QUALITY	3		3		3	2	2	3	3	0		1		
SPECIMAN STANDS	3		3		3	2	2	3	3	0				
SHORE & BANK COMM.	3		3		3	3	3	3	3	1				
FIELDS	3		3	1	3	3	3	3	3	3		1	2	
FOREST AREAS	3		3	3	3	3	3	3	3	3		1	1	
NATURAL ASSOCIATIONS	3		3		3	1	1	1	1	0				
UNDERSTORY	3		3		3	1	1	3	2	0		1		
OVERSTORY	3		3	1	3	2	2	3	2	0		0		

ATURAL RESOURCES (CONTD)	FIELD SURVEYS	GEOPHYSICAL SURVEYS	LOCAL OR OTHER GOVERNMENTAL SURVEYS	U.S. GEOLOGIC SURVEY	SOIL CONSERVATION SERVICE	AERIAL B&W PANCHROMATIC	AERIAL INFRARED B&W PHO.	AERIAL COLOR PHOTOGRAPHY	AERIAL INFRARED COLOR PHO.	PHOTOMOSAICS	ULTRAVIOLET SENSORS	INFRARED IMAGERY (THERMAL)	RADAR (SLAR) IMAGERY	ELECTROMAGNETIC IMAGERY	MULTISPECTRAL IMAGERY
ILDLIFE															
WILDLIFE TYPE	3		3		3	1	1	1	1	1					2
WILDLIFE QUANTITY	3		3		3	1	1	1	1	0					2
PRIME HABITAT	3		3		3	1	1	1	1	0					2
MAJOR ECOTONES	3		3		3										
UNIQUENESS	3		3		3										
QUALITY & PRODUCTION	3		3		3										
WILDERNESS	3		3		3	3	2	3	2	1					3
AND USE															
AGRICULTURE TYPE	3		3		3	2	2	3	2	1		1	2		3
AGRICULTURE QUALITY	3		3		3	1	1	3	3	0		3			3
RECREATION & OPEN SPACE TYPE	3		3	1	2	2	2	3	2	1					3
RECREATION FACILITIES	3		3	1	3	3	2	3	2	0					3
TOURIST FACILITIES	3		3	1	2	2	2	2	2	0					2
FACILITY STANDARDS			3												
DEMAND STANDARDS			3												
DEMAND FACTORS			3												
WATER REC. FACILITIES	3		3	1	2	2	2	2	2	0					2
URBANIZATION PATTERN (GEN.)	1		3	3	2	3	2	3	3	2		2	2		3
RESIDENTIAL TYPE	3		3			3	3	3	3	1		1	1		3
RESIDENTIAL QUALITY	3		1			2	2	3	3	0					3
RESIDENTIAL DENSITY	3		3			3	3	3	3	1			1		3
RESIDENTIAL GROWTH	1		3			2	2	2	2	1					2
RESIDENTIAL AGE	3		3			2	2	2	2	1					2
COMMERCE TYPE	3		3			3	3	3	3	2		1	1		3
INDUSTRY TYPE	3		3			3	3	3	3	2		1	1		3
INSTITUTIONS & SERVICES	3		3	2		3	3	3	3	1					3
UTILITIES	3		3	2		3	3	3	3	1					3
AIR TRANSPORT	3		3	3		3	3	3	3	3			1		3
RAIL TRANSPORT	3		3	3		3	3	3	3	2					3
WATER TRANSPORT	3		3	1		3	3	3	3	1					3
ROAD TYPE	3		3	3		2	2	3	2	1					3
SCENIC HIGHWAYS	3		3	1		2	2	3	2	1					3
PROPOSED HIGHWAYS			3	1											
ACCESSIBILITY	1		3	1		2	2	2	2	1					2
ENVIRONMENTAL HAZARDS	3		3			2	2	3	2	1					3

NATURAL RESOURCES (CONTD)	FIELD SURVEYS	GEOPHYSICAL SURVEYS	LOCAL OR OTHER GOVERNMENTAL SURVEYS	U.S. GEOLOGIC SURVEY	SOIL CONSERVATION SERVICE	AERIAL B&W PANCHROMATIC	AERIAL INFRARED B&W PHO.	AERIAL COLOR PHOTOGRAPHY	AERIAL INFRARED COLOR PHO.	PHOTOMOSAICS	ULTRAVIOLET SENSORS	INFRARED IMAGERY (THERMAL)	RADAR (SLAR) IMAGERY	ELECTROMAGNETIC IMAGERY	MULTISPECTRAL IMAGERY
LAND USE (CONTD)															
HISTORICAL & CULTURAL	3		3	1		2	2	2	2	0					[illegible]
VISUAL CHARACTER	3					2	2	3	2	1		1	2		[illegible]
LAND COSTS			3			1	1	1	1	1			1		1
POPULATION CHAR.	1		3			1	1	1	1	1			1		1
SOCIO-ECONOMIC CHAR.	1		3			1	1	1	1	1			1		1

KEY

3 = EXCELLENT CAPABILITY (BEST SINGLE SOURCE)
2 = GOOD BUT NEEDS SUPPORTING INFORMATION
1 = LIMITED USE AND NEEDS OTHER SOURCES
0 = RESOLUTION SCALE OF LIMITED VALUE
BLANK = NOT APPLICABLE

This table is based upon a variety of resource check lists (101.22) and should not be taken as a model for the classification of resource variables. The evaluations on this table reflect the opinion of D. Way, Steinitz Rogers Associates, January, 1970. As in all technical systems, the capabilities are subject to change.

limit their general overall use. Local data sources such as Soil Conservation Service field agents and Weather Bureau stations are able to supply accurately most of the general data providing accuracy checks on interpretations.

To make final selections of data sources and sensors, each specific planning project has to be examined carefully. The site location, its size, the amount, relevance and accuracy of existing information, the detail of information and accuracy needed, the schedule and budget, and the analytic flexibility required are some of the major factors that influence the final form of data acquisition.

F. Data on Demand Factors

A resource information system typically concentrates on the recording and analysis of the supply of resources. This analysis will always be of limited usefulness if there is no information on the potential demand for the resource supply. In general it is the case that a great deal of data exists on demand factors at both the local and national levels. As much as is appropriate and possible these sources of data on demand should be incorporated and utilized. These data would include the range of information available in the U.S. Census, such as basic demographic, economic, and social data. A data system for planning purposes also should include a property file for the area served by the data bank, containing data relating to individual parcels of property. Local government and private sources such as gas, electric, transportation and telecommunication companies are valuable sources of these demand data.

The development of resource information systems is usually carried out by persons with little experience and few skills in the handling of demand data. As such it would appear to be imperative that a resource system should rely on demand data which have been collected by other agencies. As this requires no investment in data collection, the cost that is involved with the conversion of other agencies' data files to a set of spatial descriptions that are compatible with the resource information will amply repay the effort.

CHAPTER III

DATA CATEGORIES

A. Zone Sets and Classification

A resource information system requires the management of a wide variety of different types of information. It is convenient to consider the different categories of information as if each is a part of a specific set of zones which must entirely fill the spatial extent of the study region, each set of zones to be overlaid over the others. The zone sets describe a grouping of data categories by the general characteristics of their content. Within each of these zone sets the information must be further broken down into the detailed categories of the data which will be stored. These sets would include:

Climatic Zones
Geologic Zones
Landform Zones
Soil Type Zones
Vegetation Zones
Watershed Zones and Water Networks
Land Use Zones and Transportation Networks
Ownership Zones
Sociopolitical Zones
Economic Zones
etc.

The concept of sets of zones is very useful when organizing the general groups of data but one must realize that any specific study will be concentrating on only a few of all the possible zone sets. The rest of the zone sets will be treated only in a general sense or, in some cases, not at all. Therefore, an information system should be dynamic in that it can be continually expanded or updated. The organization of data into categories at the initial stages of creating an information system should reflect the immediate priorities for the use of the data.

Several general issues should be considered when establishing the data categories.

1) Each zone set must be fully described. Every category or condition existing within that zone set must be included in the inventory. It is usually useful to have a "junk category" which includes all the relatively insignificant conditions which do not fit into any other category.

2. The detail to which any category is recorded should be directly related to the requirements

for the use of the data. Unnecessary detail just increases the time and cost associated with collection, storage, retrieval and analysis of data. It is usually more efficient to add increased detail as the demand for its use occurs, rather than collect a great deal of unused information. In some collection procedures it may be more efficient to collect all the detailed data at once, but even in this case reasonable foresight as to potential use must still be exercised.

3. The detailed definition of data categories should be based on a series of characteristics which can be easily identified and are relevant to the data use. Categorization for its own sake is a waste of time and will lead to problems both in the collection of data and in its later use. Two data categories that exhibit the same characteristics and are difficult to differentiate can more profitably be regarded as one category.

4. When the information system is designed for use on a digital computer system, it is very important to remember to completely describe each zone set within the system. The computer will consider the region a complete system and gaps in the data which it is given will lead to erroneous results. If a zone set only refers to a limited portion of the region or study area, the remainder of the region must be referenced as a sub-zone which lacks the relevant characteristics.

The importance of considering the various zone sets is highlighted by considering a military reservation. If coded simply as a military reservation in land use, it would be very difficult to determine the reservation's capabilities for future use if it were deactivated. Military reservation is an ownership classification and within that reservation may exist recreational, residential, semi-industrial, and just simply open space as land use classifications.

Similar problems occur with National Parks and Forests. For instance, the type of forest that exists within a region is a characteristic of the region's vegetation, while the use of that forest is characteristic of land use. As such, forest type will be coded as a vegetation zone, but the type of use made of the forest, such as management for forestry, or preservation of the forest as a wilderness area, is a land use characteristic. One must beware of confusing ownership with land use. Wilderness areas may be owned by the Forest Service or a paper company just as both organizations may also manage forests for commercial use. In general, it requires several sets of overlaid zone sets to fully describe the characteristics of an area.

B. The Selection of Data Variables

The selection of data to be included in the inventory is based upon availability and anticipated needs. Under no circumstances should a data bank be an all-inclusive data depository. Data collection is expensive and must be approached with efficiency. Since the design of the data bank must be compatible with its use and since its use is often unpredictable, the data bank must be expandable and able to be updated.

A study of resource analysis systems (101.22) has shown that, at the data inventory stage, there is in many of the studies a distinct relationship between the range of data inventoried and the breadth of purpose of the resource analysis. It was also found that technical capability in handling information was probably a constraint on the level of detail of the data collected. Table III.1 lists the major data categories which are either inventoried or used in the various methods.

This table must be considered within the analytic goals of the studies. These vary from a classification of soil types [Hills (93), Soil Conservation Service: 1, (99), Christian (91)], to a broad analysis of potential land use [Lewis (94), McHarg (96), Toth (102)], to a very specific land use study [RECSYS (98), Allison and Leighton (89)], to studies which do not deal directly with land use but with its visual impact [Litton (95), Research and Design Associates (104)].

It must be noted that the major financial support of work in resource analysis comes from government, and specifically from agricultural departments of government. Thus, several of the methods deal specifically with regional development for agriculture and forestry. The work of Hills (95), Christian (91), and the Soil Conservation Service: 1 method (99) are specifically related to these kinds of development, through broadened to include others.

The Chester County study (90), much of Lewis' (94) and McHar's (96) work, and the study by Toth (102), among others, investigate broad land use categories and their applications on site regions. They deal with agriculture, recreation, and urbanization in order to define where the landscape can absorb urbanization and where landscape can best be put to use for agriculture, open space, forest, etc.

BLE III.1 FREQUENCY OF USE OF VARIABLES

TURAL RESOURCES	1 Alli.-Lei.	2 Chester Co.	3 Christian	4 Dearinger	5 Hills	6 Lewis	7 Litton	8 McHarg	9 PARIS	10 RECSYS	11 SCS:1	12 SCS:2	13 Toth	14 Corp Eng.	15 Williams	16 Res. Pl. & Des.	17 St. Rog. Assoc.
LIMATE, General		X	X	X	X	X		X		X	X	X	X	X		X	
Rain		X		X				X			X			X		X	
Snow		X						X			X			X		X	
Temperature		X		X	X					X	X			X		X	
Radiation								X									
Fog				X				X									
Wind		X		X						X				X			
Frost						X		X									
Storms		X	X	X						X						X	
Air Drainage	X														X		
EOLOGY, General			X	X	X			X		X		X	X	X		X	
Bedrock Outcrops				X		X	X	X					X				X
Bedrock Type	X		X	X	X			X		X	X		X				X
Unique Formations	X		X	X		X	X	X					X		X		
Stable Formations				X				X			X						
Depth to Bedrock	X		X	X	X			X			X		X				X
Building Materials						X					X		X				
Structural Type		X	X			X		X			X						
Structural Age		X	X					X			X						
Weathering Type			X								X						
Volcanic Activity			X														
Economic Minerals								X					X		X		
ANDFORMS, General			X			X	X				X	X	X	X	X	X	X
Unique Features			X			X	X				X	X	X				
OILS, General			X	X	X	X		X		X	X	X	X	X	X	X	X
Soil Type		X	X	X	X			X			X		X		X		
Soil Texture		X	X	X	X			X			X		X				X
Soil Depth	X	X	X	X	X			X			X		X				X
Drainage	X	X		X	X			X			X		X				X
Erodability		X						X			X		X				
Bearing Capacity		X		X				X			X		X				
Permeability		X		X	X			X			X		X				

	1 Alli.-Lei.	2 Chester Co.	3 Christian	4 Dearinger	5 Hills	6 Lewis	7 Litton	8 McHarg	9 PARIS	10 RECSYS	11 SCS:1	12 SCS:2	13 Toth	14 Corps Eng.	15 Williams	16 Res. Pl. & Des.	17 St. Reg. Assoc
Instability		X						X			X		X		X		
Stoniness	X	X			X						X		X				
Soil Productivity					X	X		X			X		X				
TOPOGRAPHY, General	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Elevation				X	X	X	X	X		X	X				X	X	X
Excessive to Utilities	X	X				X		X			X						
Ravines						X											
Rim of Slope						X											
Relief Variation					X	X		X		X	X				X	X	X
ORIENTATION, General		X				X	X	X			X		X				X
WATER, General		X		X		X	X	X		X		X	X	X	X	X	X
Watersheds		X		X				X					X				X
Drainage Patterns		X	X	X	X	X		X		X	X		X	X			
Ground Water			X	X		X		X			X		X	X	X	X	
Aquifers		X				X		X			X		X				
Surface Water	X	X		X		X		X					X	X	X		X
Lakes	X		X	X	X	X	X	X		X		X	X	X	X	X	X
Rivers and Streams	X	X		X		X		X		X	X	X	X	X	X		X
Wetlands				X		X		X			X		X		X		X
Springs				X		X							X				
Waterfalls				X		X							X				
Floods					X	X		X			X		X		X		
Quantity				X							X		X				
Quality	X			X		X		X		X	X		X				X
Temperature				X	X			X		X							
Dis. and Sus. Solids				X	X			X		X							
Biologic Productivity				X	X			X		X							
Shoreline Type	X				X	X				X							X
Shoreline Quality	X				X	X				X							X

	1 Alli.-Lei.	2 Chester Co.	3 Christian	4 Dearinger	5 Hills	6 Lewis	7 Litton	8 McHarg	9 PARIS	10 RECSYS	11 SCS:1	12 SCS:2	13 Toth	14 Corps Eng.	15 Williams	16 Res. Pl. & Des.	17 St. Rog. Assoc.
GETATION, General	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Quality		X		X	X	X		X			X						
Specimen Stands	X	X		X	X	X		X							X	X	
Shore and Bank Commun.						X					X						
Fields				X							X						
Forest Areas		X		X	X	X		X			X		X	X	X		X
Natural Associations		X			X	X		X			X		X		X		
Understory	X			X	X			X									
Overstory	X				X			X									
ILDLIFE, General	X		X	X	X	X		X			X	X	X		X	X	
Quantity	X					X						X					
Prime Habitat				X	X	X						X	X			X	
Major Ecotones				X	X			X					X		X		
Uniqueness			X	X	X	X											
Quality & Production				X	X	X									X		
Wilderness					X												
AND USE																	
GRICULTURE, General		X	X	X	X	X		X			X	X	X		X	X	X
EC. & OPEN SPACE, General	X			X		X		X	X	X		X	X		X	X	X
Recreation Facilities	X		X	X	X	X			X	X			X		X	X	X
Tourist Facilities	X		X			X				X				X			X
Facility Standards								X	X	X					X		
Demand Factors	X			X					X	X					X		
Water Rec. Facilities	X			X	X	X		X	X	X			X		X		X
RBANIZATION, General		X		X		X		X	X	X		X	X	X	X	X	X
ESIDENTIAL, General		X						X					X			X	X
Quality								X								X	X
Growth						X		X									X

	1 Alli.-Lei.	2 Chester Co.	3 Christian	4 Dearinger	5 Hills	6 Lewis	7 Litton	8 McHarg	9 PARIS	10 RECSYS	11 SCS:1	12 SCS:2	13 Toth	14 Corps Eng.	15 Williams	16 Res. Pl. & Des.	17 St. Rog. Assoc.
COMMERCE, General	X							X		X						X	X
INDUSTRY, General								X						X		X	X
INSTITUTIONS & SERVICES								X						X			X
UTILITIES						X		X		X				X			X
AIR TRANSPORTATION														X			X
RAIL TRANSPORTATION														X			X
WATER TRANSPORTATION								X						X			X
ROAD TRANSPORTATION	X	X		X		X	X	X	X	X		X	X	X	X	X	X
Road Type	X			X		X	X	X		X			X		X	X	X
Scenic Highways						X	X						X				
Proposed Highways						X	X	X					X				X
ACCESSIBILITY	X		X	X				X	X	X		X	X		X	X	X
ENVIRONMENTAL HAZARDS	X		X			X		X									X
HISTORICAL & CULTURAL				X	X	X		X				X	X		X	X	X
VISUAL CHARACTER	X		X	X	X	X	X	X		X			X		X	X	X
LAND COSTS	X							X							X		
POPULATION CHARACTERISTICS				X					X	X		X		X	X	X	X
Population Projections						X		X	X	X					X		
SOCIO-ECONOMIC CHARACTER.	X			X		X		X	X	X		X			X	X	X

This table is based on a variety of resource check lists and should not be taken as a model for the ordering of variables.

Camping and boating are among the more specialized applications of resource analysis. The California PARIS (97) and the Michigan RECSYS (98) models take their essentially supply-oriented evaluation methods into these types of planning. The Williams (103) study is unique, however in that it develops specific resource-based strategies of implementation.

It seems clear that designers as well as planners are able to make use of resource analysis methods. The work of Litton (95) and Research Planning and Design Associates (104), and the relationships that McHarg (96) proposes between development types and topographic types indicate the possibility of a much greater degree of integration between the descriptive techniques that investigators use to inventory an area and the essentially prescriptive techniques which are required to plan for, or to predict the effects of, development on that area. While most of these methods focus on planning goals, it is clear that the goal of visual quality can also be included.

Regardless of the style of its resource analysis, a method, if it is to be useful in planning policy, must be able to integrate demand measures. With varying degrees of expertise, several of the methods attempt to include demand and economic factors in their inventories and analyses. In their studies of camping and recreation, Allison and Leighton (89), Dearinger (92) and the Soil Conservation Service (99, 100) attempt crude measures of demand. The California (97) and Michigan (98) studies make these measures as applied to recreation on a much more sophisticated basis. Toth (102), the Chester County planning group (90), and McHarg (96) attempt measures of demand for urbanization in their rating evaluations of various sites for potential urbanization.

It is clear from the list of data categories that while most of the studies require a general knowledge of a wide range of resource information, each study has a series of specific sets of detailed information that is quite unique. In some cases this was determined by the availability of information and in other cases it was determined by the requirements of the analysis procedure.

It must be emphasized that data inventory is a costly process. It would seem therefore that an inventory which is usable for a variety of analytic goals and purposes would in the long run be a more efficient and economical procedure than one which is used for only a single purpose. McHarg (96), Hills (93) and Christian (91) are among the other individuals who advocate comprehensive data banks and their use for analysis rather than the collection of data specific to the immediate analytic purpose at hand. However even in the initial stages of the development of a "comprehensive" information system, the priorities for the collection of data must be established in relation to the purposes for which the data will be used.

C. Scaling

Traditional methods of recording information on resources rely on alphanumeric (letter and number) codes which describe a category or condition. This information is essentially descriptive or qualitative. The use of digital computers requires a greater sophistication in the recording of information. Computers carry out arithmetic operations with numbers and this requires that data be scaled and recorded in a manner suitable for use in arithmetic procedures. If this property of computer use is not accounted for in data categorization, problems of statistical validity of complex quantitative analysis procedures will arise.

Data variables can be internally scaled in many ways but for arithmetic manipulation there are four basic types of data scaling: nominal, ordinal, interval and ratio.

Nominal scaling is essentially qualitative; "types" are identified without being relatively ordered on a scale. Thus, Oak vs. Maple vs. Pine vs. etc., is a nominal scaling.

In ordinal scaling, relative ordering can be assigned but it implies no relative magnitude between scale values. Thus, Oak (more valuable than) Maple (more valuable than) Pine, etc., is an ordinal scale.

In interval scaling, relative distance as well as order are significant. Thus, in the interval scale: 100°, 90°, 60°, etc., the distance between 100° and 90° is closer than that between 90° and 60°.

Ratio scaling is similar to interval, except that a fixed base value is established thus allowing quantitative values to be expressed as ratios. For example, a board foot of Oak is worth twice one of Maple and four times one of Pine. Length, density, price and many other standard measures are ratio scales. These are the highest level of measurement and can be analyzed as mathematical functions. Only interval or ratio scales may be used with most statistical analysis programs.

D. Categorization

For any variable, it must be decided how many levels of internal differentiation should be applied. This again depends on user requirements, but as a rule, ten levels are sufficient both for most variables and as a practical maximum for map legibility. A data system which is computer based can accomodate data at a very fine internalscaling e.g., topographic elevation to the nearest foot or percent of area to 1%,and then aggregate these into coarser levels as the user specifies.

When defining the scaling of a large number of variables it is important to remember that an analysis which combines several variables can be accurate only to the degree of specificity of its most coarsely scaled variable. In all cases, data categories must be determined on the basis of measurable characteristics of the conditions being studied. Some categories such as Soil Type have at least two very basic characteristics that are of little relation to each other (e.g., bearing capacity and productivity), and thus require multiple coding. In this example, the productivity is dependent on the organic content while the bearing capacity is dependent on the mixture of the granular structure of the soil. Thus, at the extreme, the absence of soil or open bedrock has no productivity but a very high bearing capacity. Similar problems exist with residential land use which has density characteristics as well as value characteristics, both of which are very important.

Ideally,the actual value of the variable should be recorded for every point location. The technical problems of data storage are such that this is often impossible, and itbbecomes necessary to divide the range of values into groups which have similar ranges of characteristics. This involves a process of data generalization or rescaling of the data.

The purpose of rescaling is to identify those groups which are significant to the analysis proposed for the use of the data. A scale which is too general will be useless for analysis purposes and a scale which is too detailed will be too costly and inefficient.

It is very dangerous to make definite statements about the rescaling of specific data categories as a set of data categories relevant to one region may be irrelevant for another. Simply, what is relevant for one problem may be irrelevant for another problem.

In general, a large and well-managed information system would usually be operated on two levels. One level would consist of the original data collected in detail and stored. At its operating level, all the data would be generalized in the manner found to be most useful for the day to day operation of the system. The user's requirements would determine this. As these requirements change,the original data would then be reprocessed to create a new set of generalized data.

CHAPTER IV

SPATIAL DESCRIPTION

In order to effectively describe spatially distributed data for analytic purposes, it is necessary to be able to include as data a location as well as the characteristic quantity or quality which results from each measurement. Having done so the analyst has added an entirely new dimension to his data as well as to its potential interpretation, i.e. space and the spatial distribution of the phenomena measured.

There are a number of considerations which will define the procedures used to describe and analyze spatial location. These include 1) defining the study area, 2) geocoding, and 3) measuring and recording locationally defined data.

A. Defining the Study Area

Defining the study area raises all the classic arguments and questions involved in defining regions. These issues are particularly relevant to public lands, whose borders rarely, if ever, reflect resource or demand system boundaries, but do reflect a control or implementation boundary.

1. Political Borders

The study areas selected for the surveyed resource analysis methods vary greatly in size, but in most instances they are politically bordered. Clearly, this decision is determined largely from the viewpoint of planning implementation. Funds are given, laws are written, political decisions are made, etc., on the basis of political jurisdictions, such as counties and states. Among the scales of political jurisdiction used are multi-state regions [Research Planning and Design Associates (104), Lewis (94)], states [Lewis (94)], counties [Chester County (90), Soil Conservation: 1 (99)], and townships [Toth (102)]. These are a convenient and often necessary simplification. Yet no natural resource arranges itself spatially on the basis of politically defined borders.

2. Property Line Borders

The equivalent problems are raised in the private sector by resource analyses of lands in which property lines of owned or controlled lands determine the borders of the study region, and in studies of public lands where the borders of the public lands define the study area. These are also suspect from the viewpoint of resource analysis. In both cases inventories can be made, but one cannot predict the consequences of action or policy, either from outside the area onto the study area, or from the study area to the adjacent lands. The smaller and more complex the study area, the more this is a problem.

3. Watershed Borders

A popular site-defining characteristic is the watershed, and these range from the very large Upper Mississippi River Basin as studied by Lewis (94) to the smallest scale subwatershed studied by the Dearinger (92) group. Yet demand variables are not to be found on the basis of these resource-defined units, particularly within the smaller ones.

4. Demand Area Borders

The resource studies which also analyze demand typically take a broader view in defining their study area. The Williams (103) and Dearinger (92) studies, and the RECSYS (98) and PARIS (97) models each recognize that demand comes from a larger area than the ultimate supply of resources to which that demand is attracted. Urban areas at distances up to 300 miles from a resource study area are typically considered in determining the area of potential demand.

5. Some General Issues

A major consideration in the definition of the study area is its influence on the accuracy of the analysis. All of the studies assume uniform accuracy within their various study areas. Yet this assumption must in many cases be doubted, particularly the edges of the geographic areas. For example, it is clear that State Parks on the edges of Michigan receive demand from neighboring states and equally clear that urban dwellers on the edges of Michigan go to neighboring states for recreational activities. This applies to almost every study from both the supply and demand sectors. Without defining an area of influence for each study area, it becomes impossible to plan accurately resource use.

In general, the "free body cut" should be made around the smallest area which encloses all the data zones and systems which impinge on the geographical area or content under study. All data systems are then assumed to be closed within this area, an assumption which, in the light of the "spaceship earth" concept, must be heavily qualified. The area for which data are available should therefore always be larger than or equal to the area of interest. Political and physiographic data borders will rarely be as satisfactory as a somewhat arbitrary larger border which will include within it the relevant political or physiographic areas of interest.

B. Geocoding

Geocoding, or geographic coding, is a procedure for recording as a part of one's data the locations at which data are collected. For each data record, one or more geocodes such as land parcel number, county name, or latitude and longitude coordinate are added to that record in order to identify the location to which the data refers. Geocodes provide two basic capabilities: (1) referencing or identifying each record; and (2) increasing the flexibility with which one may manipulate his data.

1. Referencing

During the initial data collection process it may at times be necessary to refer back to the original location from which the data was derived for the purpose of locating missing data or for verifying the accuracy of the data as recorded. In addition, at a later point in time it may be necessary to recollect the data in order to establish a second set of data which will be compared to that collected earlier. In both cases it will be necessary for the investigator to be able to identify the locations of each original data measurement.

2. Data Manipulation

The summarization of individual observations to create a total for a larger area requires that it be possible to associate each observation with the larger area of which it is a part. For example it may be necessary to aggregate measurements of land use for each parcel of land in order to calculate a county total for each land use.

The merging of data which has been collected by two or more independent agencies for the same area requires that the records of each contain location identifiers or geocodes which are or can be made compatible. The combining of U.S. Census data with that of natural resource data derived from aerial photographs illustrates this problem.

The selection of all records which contain observations recorded at a specified distance or direction from a given point requires that the relative location of each point can be known. Determining the number of acres of a particular type of land use within a five mile radius from a given point is an example of such an application.

The same criterion holds true in the calculation of distance measures within which a given criterion is satisfied. In this case, one might wish to establish the continuous extent (distance and direction) of a particular land use.

Finally, mapping is dependent upon being able to associate the locations at which the data have been collected with their location on the map which is to be produced.

Whatever system of geocodes one chooses to use, it is desirable for that system to extend beyond the limits of an initial study area. Having done so, it then becomes possible to extend the initial study area in a consistent manner at some later point in time; but even more important the data, as collected, are compatible in terms of their locational identifiers with those collected elsewhere.

3. Geocoding Metrics and Referencing

a. Definition

A geocoding system must be based upon a consistent metric if one wishes to use his data for the purpose of deriving spatial statistics and/or the preparation of computer maps. In addition, the geocodes should be based upon a reference system which extends in a consistent fashion over, and preferably beyond, the study area. The reference codes should also be identified on maps available from governmental sources. Geocodes which meet these criteria include x-y codes based upon latitude and longitude, state plane coordinates, and the UTM grid.

Commonly used geocodes which do not by themselves exhibit these properties are street addresses, census block and forest tract numbers, county names or codes, and range, township and section designations. The lack of a consistent metric in each of these units prevents the user from being able to determine the relative location (distance and direction) of any two points which have been described by one of these latter systems. The use of codes of this type in one area has little or no consistent spatial relation to similar codes in other areas and therefore are very difficult and often impossible to interrelate.

b. Properties of x-y Coordinate Systems

Any data which are to be mapped by computer must be identified by numerical x-y coordinates which describe the relative location of each geographic unit. In the evaluation of coordinate systems for the recording of large amounts of data, the following requirements should be considered:

1) the coordinates should be compatible with systems used elsewhere and should be equally convenient for use at a local or a national level;

2) the coordinates should provide a rapid method for determining a position within the accuracy desired;

3) the coordinates should be useable for existing as well as likely future applications and equipment; and

4) the coordinates should permit accurate and economical formulae for computation.

Accuracy and economy of computation are somewhat contradictory. High degrees of precision are available when geodetic formulae are used, but often only by performing complicated calculations.

As a rule, the accuracy of a coordinate system need not be any greater than that with which the associated data has been recorded or that which is required for its use.

(1) Latitude and Longitude

The most universal system of location identifiers is latitude and longitude. The use of these codes provides a worldwide system of locational identifiers. The fact that this system is based on the earth as a sphere makes it possible to account for the curvature of the earth when one is dealing with a study area of sufficient size for this factor to be significant. Unfortunately projections of the curved earth onto a flat map sheet necessarily introduce distortions, particularly on area calculations. However, map sheets based upon a known projection with specified control points (such as USGS quadrangle sheets) make it possible to accurately calculate and compensate for the actual distortions present in such maps when one is working with a computer using data system. This is, however, an added calculating expense.

(2) State Plane Coordinate System

The orientation of this system is towards the individual states. This system is suited to the needs of the local surveyor and has been officially adopted by many local government units. State plane coordinates appear on all U.S. Geological Survey topographic maps. Either the Lambert Conformal Conic projection or the Transverse Mercator projection is employed, depending on the shape of the state. Approximately 120 zones cover the entire United States giving an accuracy in each zone of about one part in 10,000. Conversion formulae from state plane coordinates to a latitude-longitude coordinate system can be performed. However, when a study area extends across state boundaries, and therefore across state plane coordinate systems, it is necessary to convert from one state's system to another. Similarly, within a given state there may be several state planes. It should be recognized that these systems were designed for use by surveyors in describing tracts of land within a given state and not for interstate use nor for deriving spatial statistics.

(3) Universal Transverse Mercator

The Universal Transverse Mercator grid system, UTM, includes the area between eighty degrees north and south latitude, and extends around the world in sixty north-south zones, each zone covering six degrees with one-half degree overlap. The system is well-established and can be extended to include areas adjoining the United States. It is indicated on USGS maps. The accuracy within each zone is one part in 2500, and the size of the individual grid cell or data unit can be varied within the same system, according to user needs. The zonal nature of the UTM grid can lead to problems when a large study area includes portions of two or more zones. However, there are a variety of solutions to this problem, none of which is difficult to apply.

In addition, each UTM grid unit is square and of constant size, which aids in computer analysis and display; the coordinates are expressed metrically, which would reduce transitional difficulties if the metric system of measurement were adopted; and the UTM grid system is of global extent and availability. As a result of the last of these factors, the UTM grid system will undoubtedly be used to reference satellite photography and other remote sensor data, which may, in time, provide the major portion of natural resource data.

c. Transforming x-y Coordinates

The three forms of x-y coordinates discussed above are capable of being mathematically transformed from one system to another. An example of a computer program designed for this purpose is described in a technical report prepared by the U.S. Coast and Geodetic Survey (1). This particular program is capable of transforming coordinates between any two of the following systems: state plane grid systems based on the transverse Mercator or Lambert projection, geographic position (latitude and longitude), secant plane, geocentric, and Universal Transverse Mercator (UTM) grid.

C. Spatial Types

1. Types of Spatial Data

Having established the characteristics of various x-y coordinate systems, it is important to note that in each case a given pair of x-y coordinates defines a point. For purposes of defining locations it is necessary to recognize two additional locational descriptors: lines and areas. Taken together, points, lines, and areas make it possible to adequately define the location of any feature or activity on the earth's surface.

a. Point Data

Data which are uniquely associated with a specific location and are assumed to have no areal extent are point da The definition of "no areal extent" will vary with the scale of a study. True point data, such as the location of a specific tree or water tower, must not be confused with pseudo point data, such as the characteristics of an area like a town or forest tract which have been associated with one point, usually the central point of a large zone. Pseudo point data is a simplification which has been used a great deal because of the ease with which points can be organized. Provided that the data which are being studied can be assigned to one consistent and unique set of zones (such as census tracts or counties), it can very logically be assigned to pseudo points and analyzed as though it is point data. However, natural resource and land use information do not usually conform to a single unique set of zones.

b. Line Data

Lines represent a set of points which are related by a characteristic of connectivity and often by the extra attribute of directionality. The location of lines may be defined by two or more points. Straight lines require only two pair of x-y coordinates, one at each end of the line. Lines which are continuous but composed of two or more angular straight line segments are described by coordinates defining the two extreme end points plus a coordinate at each location where the line changes direction, i.e., each vertex. Curved lines may be approximated by a series of straight line segments, with the precision of the curve as recorded being a function of the number of segments used to approximate the curve. Just as with areal information, in resource analyses, linear information usually occurs as a series of overlaid systems such as water systems and transportation systems.

c. Area Data

At the finest level of generalization, all information is point data. However when studying a spatial region it is convenient to identify areas or zones of known and constant characteristics. Thus each zone can be regarded as a bounded set of points which have the same characteristics. That is, a forest zone is a set of points representing individual trees. It should be emphasized that most natural resource and land use information represents a series of overlaid sets of area zones. The definition of an area is quite similar to that of curved lines. However the first and last point defined are either implicitly connected, or the user is required to repeat the initial coordinate in order to explicitly close the area.

D. Zones for Data Grouping

The ways in which data are spatially grouped determine how well one can retrieve the information spatially at a later time. They determine the feasible ways in which one can:

- aggregate or group the information geographically;
- examine or describe geographic relationships, such as distances between units of data;
- display geographic relationships, such as in maps, movies or three-dimensional models.

Several distinct styles or approaches can be seen in existing studies which may be categorized by the manner in which each considers the spatial nature of the data.

1. Single Predefined Zones

Several methods treat large, predefined areas as homogeneous in terms of the evaluated resources. Michigan (98) considers each State Park with a single evaluation. The Allison and Leighton (89) method and the Soil Conservation Service: 2 method (100) treat potential campsite areas similarly. The Dearinger study (92) analyzes resources for both supply and demand on the basis of subwatersheds which are assumed to be uniform, and these can be rather large given the purpose of the method. The United States Census works exclusively with a hierarchical system of predefined zones, such as blocks, tracts, towns and counties. While the assignment of a single evaluation of description to a large area greatly simplifies the task of the analyst, he also falls prey to the chance of invalidity in the assumption of homogeneity within his description. It is doubtful whether a given watershed is uniformly covered with forest or that it is uniformly excellent, good, or poor for recreation.

2. Natural Resource Defined Zones

Several of the methods, such as those of Research and Design (104) and McHarg (96) allow the spatial spread of the resources themselves to determine the data zones. These typically use the techniques of preparing overlays for each resource, with each overlay being to a common scale and coming from whatever represents the best source of information. When overlaid with each other, these maps define areas for which the assumption of homogeneity is made. While an appealing method, this technique often makes a hidden assumption at an early stage in that most of the sources from which the overlays are made often dichotomize the data variables. Thus, on the USGS maps, areas that are considered forest are green and areas which are not in forest are other colors. If one makes an overlay with lines drawn around the forested areas, one is in fact saying that there are no forests in other areas. This is a judgement which is at a lower level of specificity than it needs to be, since several other techniques can identify different densities and types of vegetation on the basis of more areas. Clearly the person who uses somebody else's inventory in making an analysis, limits his analysis by the quality of the inventory data which he is using.

The lack of specificity within the zones is a product of hand drawn technology that has been used in the past. The applications of computers to this type of system have made a major increase in the ability to handle more specific and numerous sets of areal zones.

3. Single All-Purpose Zones

It is in the inventories of resources for large undeveloped areas, notably those which would be based upon a combination of aerial photographic analysis and field work, in which the search for an all-purpose data zone becomes the key aspect of the method. Hills (93), Christian (91) and the Soil Conservation Service (99) among others seek, through the progressive interpretation of resource characteristics such as landform, soils, and vegetation, to identify hierarchical orders of land units which can be used for various inventory and evaluation purposes. They try to identify the smallest unit which can be efficiently used as the basis both of inventory and evaluation, as well as for planning. While their methods of identifying these levels and units vary, their goal is essentially simila

The all-purpose data zone is designed to eliminate the overlay procedures that are often used in analysis. It presupposes a set of analysis purposes as part of the data inventory procedures. For essentially undeveloped areas, this search for a resource based data zone of homogeneous character is perhaps adequate. However in a developed context in which demand analyses must be included in planning, the sources of data on the demand side cannot coincide with a zone which is defined on the basis of resources.

The predefined zones and the all-purpose zones have been used because of the immense labor that is involved with the collection and analysis of information that is collected on the basis of natural resource zones. However, digital storage and retrieval techniques provide a tool which can handle natural resource zones more efficiently.

One finds himself in a bind in deciding which data zones to identify. On the one hand, political zones which provide much of our demand data, such as those defined in the census, are unsuitable for resource analysis; and on the other, naturally defined zones which one can identify by a variety of methods are not the zones from which the sources of demand data are available. Here, depending upon the nature of the study area and the purpose of the method, one either takes his choice or, as is done by grid geocoding, attempts to approximate all of them.

E. Spatial Accuracy

The scale and detail of data zones are of prime importance when data are collected and stored. A resource evaluation which combines a variety of data from a variety of sources is only accurate to the level of its coarsest component, and consistency in scale among the various data is rarely adequately considered in resource analyses. When conversion of data observations to grid coordinates is made, these considerations must be explicitly faced. Once the data have been converted, they are "locked in" and it is very difficult to disaggregate or reorganize them.

The spatial accuracy which can be achieved is constrained by the detail of the original definition of the boundaries of the data zones, and this is a function of the resolution of the grid coordinates. The optimum cell size for the data must be considered before data are stored. Too little detail will be detrimental to later analyses, and too much detail will result in excessive cost.

In every case, be it the definition of points, lines, or areas, it is important to recognize that every measuremen is only an approximation of a location. The actual precisio used may vary greatly, but decisions in this regard should reflect the precision required, particularly in relation to the accuracy with which other variables are being recorde at this location, the uses which will be made of the data, and the resources available (dollars, time, and people).

The spatial accuracy of data analyses are limited by th coordinate grid cell size of the stored data. Thus, for point data (for example, at a scale of a 1 km. grid, the location of elementary schools), one knows the coordinates of the cell in which the point is located, but one cannot specify the location within the cell. On the other hand, it would be quite possible to specify absolute pin-point accuracy on any point data by adding extra digits to the coordinate coding system. For line data (for example, at this scale, traffic flows), one can specify flows within cells on any route but not the exact alignment location of the route within the cell, and one can specify origin and destination cells but not necessarily routes. Again, if one knew the location of a specific route between two points, it could be specified cell by cell. For area data (for example, at this scale, the percent of the cell of forest use) we can specify a value, but not the pattern of that value within the cell.

However, it is possible to identify consistent sets of geometric distribution patterns for various types of development. For data from multi-cell zones, such as census tracts, one cannot accurately disaggregate the value without a special study for each case. It is often possible to make estimated disaggregations based on other data that may have been collected for each grid cell, for example, the disaggregation of population density data on the basis of residential land use coverage. As a rule, though, any analysis derived from a combination of several variables from several types of zone is spatially accurate only to the scale of its coarsest data zone. Thus, efficiency versus accuracy judgements must always be made in the design of a resource analysis.

F. The Grid as the Basis for Data Handling

1. Grid Cell Size

In the selection of a grid coordinate system for geographic referencing and in the decision to use the grid cell as the basic unit for all data acquisition, processing, storage, analysis, and display, a key decision is the size of the grid cell. Among the important factors entering into the decision on cell size are the zones at which data are available and the scale of the uses to which data analyses are to be applied. In defining the grid cell size, the rule of the least common denominator can be applied: "Find the cell size which is the smallest unit resulting from the overlay of the various data zones." This cell size can be adequately aggregated into any of the zones, and by itself will lose no data detail. Figure IV.1 illustrates the schematic application of the least common denominator rule to a study area for a variety of the zones which must be considered and can be spatially superimposed. A variety of indices are used in the data bank to coordinate data cells with their appropriate aggregate source zones.

The cell size is then evaluated for its practical efficiency in data handling. There is a necessary compromise between a small basic data unit and a large one. When the data unit is small, the "natural" borders of larger data zones can be more closely approximated and the assumption of data value homogeneity, which most resource inventory methods make, is more likely to be valid. With a small unit, any study based upon the data bank can be considered in finer grain and will therefore be more useful for project planning and design. The use of the computer for data handling also affects decisions on cell size in that their ability to rapidly analyze large quantities of data allows for smaller grid cell sizes. The major advantage of a larger unit is lower data collection and analysis costs. To the degree that explicit or external processes are used, these costs can be substantial, thus arguing for a larger cell size. The scale of data use is also related to the choice of a grid unit size. For example, if one is locating industrial sites that might average 50 acres in size, it would be an advantage to have site analyses at that scale or finer. These use-sizes vary by type, regionally, and over time, and so this influence on data scale can only be based on pragmatic experience.

The authors have been involved in several studies which have given them experience in evaluating the relationship between data scale and use. Grid cell sizes ranging from one acre to four square miles were used in the following studies, which are described more fully in Appendix A.

1/250 sq. km., about 1 acre: Carl Steinitz, Congruence and Meaning: The Influence of Consistency Between Urban Form and Activity Upon Environmental Knowledge. 1966-1967. (101.16)

1/25 sq. km., about 10 acres: John Gaffney, Harry Garnham, Nicholas Quennell, Exurban Development Study. 1968-1969. (101.21)

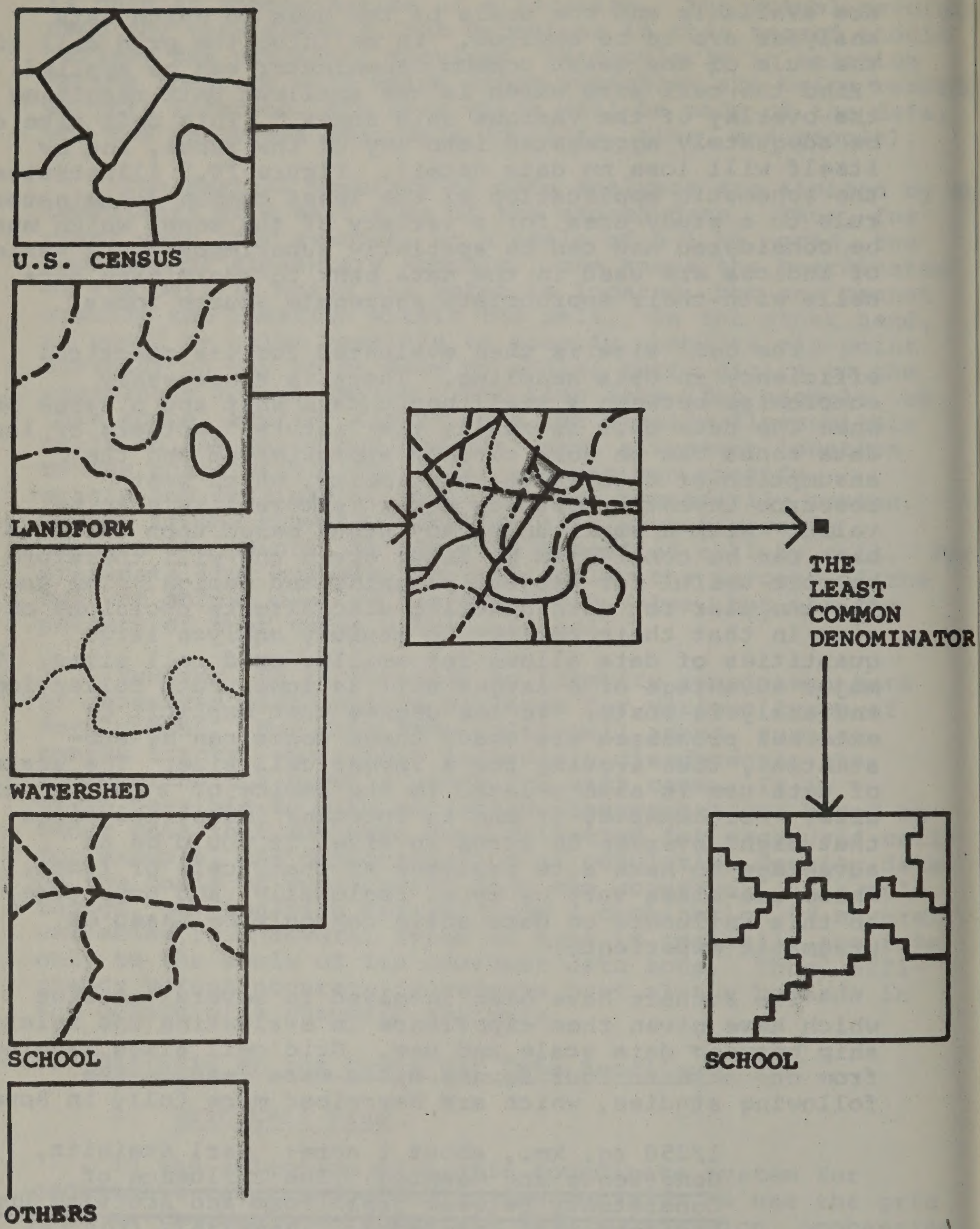


FIG. IV.1
THE LEAST COMMON DENOMINATOR

1/9 sq.km., about 25 acres: Carl Steinitz, David Sinton, et al., Boston: Metropolitan Core. Fall 1968. (101.21)

1 sq. km. about 250 acres: Carl Steinitz, David Sinton, et al., New York State Land Use and Natural Resources Inventory. 1967-1968.(101.18)

1 sq. km., about 250 acres: Carl Steinitz, Peter Rogers, et al., A Systems Analysis Model of Urbanization and Change. Spring 1968. (101.19)

2.6 sq. km., about 1 sq. mile: Eric Doepke, Thomas Mierzwa, Highway Corridor Selection Studies. Spring 1967.(101.21)

10.4 sq. km., about 4 sq. miles: Carl Steinitz, et al., Delmarva. 1966. (101.15)

2. Two Alternative Procedures

In organizing data for grid storage, a basic decision must be made as to when in the procedure the data are to be converted to the grid.

In Alternative No. 1, data are described in machine readable form in terms of their zone boundaries and are stored with this description. This requires an internal or implicit conversion of the data to a grid for processing and analysis. The Canada Land Use Inventory (86) has used this procedure, and an ideal resource system would closely replicate many of the procedures that they employ. However Alternative No. 1 has a major constraint in that it requires massive capital investment in hardware, software and manpower to make the system operational.

In Alternative No. 2, data are externally and explicitly converted to a grid before they are stored in machine readable form. The authors have used this procedure in most of their studies (See Appendix A.). It has the advantages of low budgetary requirements and relatively less sophisticated manpower requirements to handle the system.

An operating system of resource analysis should be designed to maximize the efficient use of the available resources of the agency or institution which undertakes the project. The following must be considered in determining the extent to which the simplified approach of Alternative 1 is to be used, rather than the more sophisticated approach of Alternative 2.

a. Computer Hardware

The internal or implicit conversion of data to a grid will require computers of relatively large memory size and high capability for complex data management. The efficien storage of zone boundaries will require costly off-line equipment such as a scanner or digitizer. The quality of the spatial accuracy will be a function of quality of equipment used to measure locations.

b. Software or Programming Manpower

The complexity of a computer system used to store and retrieve data is highly variable. However, as the complexit increases with internal conversion, so will the requiremen for more sophisticated software and in turn more skillful programmers will be required to manage the software.

c. Fixed Costs

Much of computer hardware and software considerations involve fixed costs. However, the more data that are involved the greater the economies of scale that can be achieved in either approach.

d. Time Considerations

The more complex the system the longer it will take to set up and become operational. Alternative 2 is now capable of producing results in a very short period of time.

CHAPTER V

METHODS OF RESOURCE ANALYSIS

A. General Goals

The analytic goals of resource analysis methods are essentially similar, but their underlying logic and assumptions differ, as do the form of their results. In most, a problem is determined, a study area is defined, and the methods are applied, having as their goal the identification of prime areas for different purposes, typically land or other resource uses.

Many resource analysis approaches make the simplified assumption that evaluations of suitability can be directly translated into development policy and implementation, not making clear the distinction between "could" and "should." Hills' definitions (93.1, pp. 2-3) of suitability, capability, and feasibility are most useful.

The concept that resource analysis should identify places in which natural resources constrain development rather than attract it, the latter implying a study of demand, would seem to be a potentially efficacious procedure. It may well be that the goals which unite some of the resource analysts would be better served by this more direct approach. Thus, in evaluating resources for development purposes several of the methods, notably those of Lewis (94) and McHarg (96), reverse the more typical suitability evaluation procedures and evaluate resource patterns or resource areas which "shall not" be subject to unconstrained development because of factors which would be detrimental to the interests of development itself. If the bias of an analytic technique is to be from the viewpoint of resources, it would seem that this analytic style, identifying the areas which are best left natural because of danger to other uses, would have many attractions. Certainly this is the area in which most of the resource analysts themselves can claim expertise.

The specifity of the resultant analysis evaluations will vary with the method used. These range from broad characterizations shown in the colored maps of McHarg (96) and in the ratings of excellent, good, fair, and poor that several methods use; to the descriptions of suitability, capability, and feasibility, each of which is internally dichotomous, as in Hills' method (95); to the several numerical point rating systems such as those of Allison and Leighton (89), Dearinger (92), and Lewis (94); to the most explicitly derived formula for state park attractiveness, that which is employed in the Michigan model (98); to the spatial explicitness in the multi-sector urban growth simulations of the Steinitz Rogers study (101.19).

Considering the grossness and lack of specificity originally inventoried in many of the variables, one is more comfortable with the broader characterizations of resources as being potentially excellent, good, fair, or poor for any given use, than with the very precise numerica evaluations. However, the resource analyst is pulled from the other side by the requirement that in order to be useful for implementation, his method must indeed rank order the resultant evaluations. He must identify the single bes area for an activity or the single worst area, and if policy and implementation do not allow the best site to be obtained, then the second, third, ninth, and one hundred and fifteenth best sites must be identified. Thus, as in many other issues, the resource analyst may be forced to make a choice between reliability and specificity. Again, obviously, the goal is to achieve both.

Methods of resource analysis can be described as having increasing levels of complexity, specificity, and probable usefulness in land resource planning and implementation. These can be characterized as:

Description;
Static, Single-factor analyses;
Static, multiple-factor analyses;
Dynamic, single-sector models; and
Dynamic, multiple-sector models.

B. Description

The first order of resource analysis is purely a descriptive inventory. Several methods identify zones of homogeneous character based on the presence of single variables or sets of variables, but do nto make qualitative or quantitative evaluations of them. It is, however, intended that their nominal descriptions be eventually evaluated for a variety of development purposes. These descriptive methods deal primarily with the supply side of natural resource analysis, and much of the work of Christian (91), Hills (93), and the Soil Conservation Service (99) would fall into this category. The studies by Litton (95) and Research Planning and Design Assoc. (104) of visual form are also essentially descriptive inventories. To the degree that it is possible, these methods attempt to establish objective measures for various resources and to avoid the introduction of subjective evaluation into the inventory stage.

The failure to recognize the distinction between objective measurement and subjective evaluation is one of the common failings of many resource studies, as evidenced in some of the methods which in the inventory stage introduce point rating evaluations. To the maximum extent possible, the inventory stage should be value free and rely on objective measurement. The Michigan RECSYS (98) study is unique in its recognition and discussion of this difference. Furthermore, it is the only one which specifically eliminates purely subjective evaluations from its analytic procedures. Clearly, substantial work must be done to increase the degree of objective measurement which can be applied to what now must still be considered subjective evaluation. The omission of important qualitative factors such as visual quality from a method which is relying upon quantitative evaluation is not the answer. Rather, one must be able to include these factors.

C. Static Analyses

Most of the currently used methods can be considered "static," in that for a given proposed use the resources are evaluated on a singular basis. Changes in the data caused by time or the intervention of man are typically not considered. Most of the investigators undoubtedly recognize that many natural resource data do change, but the technical means at hand do not allow them to include variables which are dynamic in their analyses, nor do they allow multiple analyses of a problem under differing assumptions.

1. Static, Single-Factor Analyses

Single factor analyses are rarely found because of their obvious simplicity, but at least two kinds of data are used as primary analysis sources. One is soils, with many of the soil capability studies being based upon this single, though complex, variable. Examples are found in the work of the Soil Conservation Service (99, 100). The other example is the visual studies such as that by Litton (95), which uses topography as its principle data source.

In most cases, the single factor analyses are interpretations of descriptive data. Indeed, topographic slope is a prime example of an objectively measurable variable which is used in a variety of interpretations, notably for its impact upon urbanization. The cut-off point between good and bad slope for urbanization ranges anywhere from 9 to 45 degrees. Thus, it often appears not to be the data inventory which distinguishes a method, but the interpretation of the data.

2. Static, Multiple-Factor Analyses

Most of the static analysis methods make use of several variables in their evaluations. The added complexity of combined multiple variables affords more confidence in the results, and some kinds of predictive analyses are often found in these methods. Thus Lewis (94), McHarg (96), Toth (102) and others identify areas on the basis of combining several resources in which they are prepared to make predictions of consequences of various development policies. Thus, among other patterns, Lewis identifies flood plains and predicts damage to urbanization should it occur here. Similarly, McHarg makes generalizations about increased air and water pollution in areas of potentia industrial development in his study of the Valleys. Given the level of scientific expertise and applied ecological knowledge, these broad generalizations are often the most apporpriate ones which can be made, particularly given the meager financial resources often available to the investigators. Unfortunately, the level of technical spphistication employed in these static resource analysis methods to predict ecological and other damage to the natural environment is not at the same level as that employed by the many recent models of water and other edological systems pollution. Even though they are rarely quantitatively or qualitatively specific, the static methods do quickly identify the essential issues to be considered.

The static analyses combine their multiple variables in one or more of a variety of techniques which can be classified as:

Overlays;
Point Rating Systems; and
Key Element Systems.

a. Overlays

The most common style of static analysis is that of using overlay methods, or "sieving", to identify areas with combinations of sought-after resources. In this technique, maps of different variables are made, typically in color on a transparent base. These are then superimposed and the various data combinations are in turn recorded eithe photographically or on new drawn maps. The equivalent computer program is a set of linked "if" statements.

Overlays are the fastest way to identify zones which have all of a given set of variables. However, the method does not easily identify choices which are less than best. Lewis (94), McHarg (96), Forbes (40), and others have used this method extensively. The appeal of the method rests in its simplicity and its typical graphic clarity and communicability.

Its liabilities are an inabliity to distinguis many levels of internal scaling of the variables, an inability to deal with large numbers of variables in one analysis, and, importantly, an inability to differentially weight the relative significance of different variables.

b. Point Rating Systems

Numerical point rating systems are another common method used in combining several variables in any particular analysis. In this method the presence of different variables is ascertained much as in the overlay method. However, numerical point ratings are assigned to differentially weighted variables. The points are then cumulated as the analysis incorporates additional variables, and the resultant numerical totals are assumed to be evaluations of the sought-after quality for potential development or use. The equivalent computer program is a set of weighted "if" statements.

In local studies, point rating systems are a convenient and effective method for making explicit the evaluation criteria of the analyst or his client group. However, when applying point systems to large regions, it must be recognized that explicit specification of evaluation criteria is mandatory if others are to be able to replicate the method. The common variation in point rating systems, even when applied to objectively measurable data variables, clearly indicates the degree to which personal interpretation is used in resource analysis. In analysis of very large regions, such as that in the Upper Mississippi River Basin study of Lewis (94.1) and the North Atlantic Region by Research Planning and Design Associates (104.1), and in nation-wide analyses, such as those of the Soil Conservation Service (99), the standardization of point ratings becomes a less crucial issue, since local and more relative resource evaluations are perhaps more important to development than consistent evaluation over such very large areas.

c. Key Element Systems

One of the uses of raw data employed by several methods such as those of Dearinger (92) and the Soil Conservation Service (100) is the rearrangement of raw data into key elements. In this method, overlays and point ratings are combined in an attempt to take a large number of relevant variables and combine them into a managable, smaller number of "factors". Thus, several soil and topography variables might be evaluated in a "construction costs" factor, which would in turn be combined with other complex factors in the analyses. The equivalent computer program is a set of weighted "if" statements with intermediary totals.

One potential drawback of this method is that, in combining key elements, one very often finds the same basic variable appearing many times in only slightly different guises. Thus, topographic slope or landform would appear as the basis for the definition of several key elements, and the methods do not always recognize the degree to which a final cumulative measure reflects the multiple use of a few specific variables and the singular use of others. One sometimes feels that this represents an implicit weighting system of which resource analysts are not fully aware. A second danger of this concept is that the key elements often combine variables which are basically different in their manner of measurement, some of them being based on nominal descriptive scales and some based on ranking scales. Thus key elements (in addition to summary evaluations) combine what is, in essence, apples and oranges. However this approach, when properly used, would seem to be a major convenience and indeed, given the manual methods that many of the studies use in map overlaying, the consolidation of many variables into fewer is absolutely necessary.

D. Dynamic Analyses

The dynamic methods are essentially directed to the same purposes as are the static methods, but they ask a different question, namely, "What if...?"

This is the crucial question if the prediction of the consequences -- the benefits and costs of alternative courses of action measured in a wide range of values -- is the desired analytic goal. This is the question which is of most use in policy formulation and decision making. One cannot decide what to do unless one can evaluate the consequences of the widest range of alternatives.

These methods are therefore typically developed as system models, which can be applied in multiple evaluations of the same problem under different data conditions (such as different stages of forest growth over time) or different policy assumptions (such as the selection of the least costly versus the most scenic highway location). The dynamic character of these models and their analytic flexibility are typically derived from the use of computer technology.

1. Systems Analysis Models

In the past few years, with the increased application of the techniques of systems analysis, a fairly complex and detailed methodology for modelling has been derived. This can be seen as constituting a distinct body of knowledge. Systems analysis (or operations research) can be considered a way of looking at complex problems, and Simon (79) has made the following definition of the new field:

> "Operations research is loosely defined as the scientific method or straight thinking applied to management problems. This is similar to what had earlier been thought of as 'scientific management' except that operation researchers tend to use rather high powered mathematics. The systems

> approach is a set of attitudes and a frame of mind rather than a definite and explicit theory. At its vaguest, it means looking at the whole problem -- again, hardly a novel idea, and not always a very helpful one. The mathematical tools of operations research (including linear programming, dynamic programming, game theory, and probability theory) have a general recipe when applied to management decision making: (1) Construct a mathematical model that satisfies the conditions of the tool to be used and which, at the same time, mirrors the important factors in the management situation to be analyzed. (2) Define the criterion function, the measure that is to be used for comparing the relative merits of various possible courses of action. (3) Obtain empirical estimates of the numerical parameters in the model that specify the particular, concrete situation to which it is to be applied. (4) Carry through the mathematical process of finding the course of action which, for the specified parameter values, maximizes the criterion function."
>
> [Simon (79), p. 16.]

The most important point of Simon's definition is that systems analysis is novel not merely because it includes more of the system, but because of its unique overall viewpoint. His definition is, however, rather idealistic in that he talks of maximizing the criterion function. In many practical cases of public planning, especially in problems of environmental quality, it is not directly possible to make optimizing models of the system. Under such circumstances, it is necessary to rely on the use of descriptive simulation models instead of analytic models. The distinction between these two types of models will be clarified later.

2. Types of Models

Since the word model is used loosely in everyday language, it is important to define how it is used in systems analysis. Table V.1 classifies the types of models, with some examples of their use. In a systems analysis of a particular problem, we could use any one of the types of models shown in Table V.1. However as experience increases, more and more analysis has moved away from the iconic and the analog, toward the symbolic models.

TABLE V.1. CLASSIFICATION OF MODELS

Type of Model	Example
Iconic	Architect's model of house; engineering drawings; city planners' land-use maps.
Analog	Network flow analyzer using electricity as an analog for water, gas, etc.; slide rule addition of logaritms, using length as analog for number.
Symbolic	Mathematical equations, mathematical programming, digital simulation.

Lowry (56) classified the symbolic models into (a) descriptive, (b) predictive, and (c) planning models. Descriptive models attempt to replicate the relevant features of an existing environment and are useful in formulating theory. Predictive models attempt to foretell the consequences of an action. Finally there are the planning models which strive not only to predict but also to evaluate the results in terms of the planner's goals. Lowry listed the essential steps in a planning model as:

1. Specification of alternative programs or actions that might be chosen by the planner;
2. Prediction of the consequences of choosing each alternative;
3. Scoring of these consequences according to a metric of goal achievement;
4. Choosing the alternative that yields the highest score.

This is a restatement in more general terms of Simon's (79) definition of operations research.

The symbolic models used in planning analysis can be structurally distinguished as mathematical programming models (analytic models) and digital simulation models used for optimization (simulation models).

Analytic models are based on formal mathematical algorithms. An algorithm is a set of logical rules which enable one to do mathematical operations. These models are preferred by system analysts because of their mathematical elegance and simplicity. However, they do depend upon the theoretical limit of formal mathematics (usually algebra) and hence are quite often restricted to modelling only the simplest relationships. For instance, non-linear relationships are difficult to handle by these methods.

Linear Programming is an example of a method for analytical model building which has been successfully applied in many cases. Linear means that there are linear proportional relationships between the variables. These are restricted to linear relationships and linear utility and objective functions to be maximized or minimized as need be. When the system has been modelled by these linear equations, an algorithm is then applied to make a solution to the model. Provided that the equations set up as the model of the system meet some minimum requirements, the algorithm will always give you the optimal solution (the maximum or the minimum value which is sought).

Simulation models on the other hand are in general non-algorithmic. One must create for oneself the logical relationships, which in this case are not restricted to formal mathematics but can include all formal linguistic relationships. Since it is extremely difficult to construct an optimizing algorithm from such logic, the thrust of most simulation is descriptive rather than optimizing. This creates some confusion and leads many people to believe that simulation models do not optimize. This is not necessarily true, since a descriptive simulation model can be used to make "steepest ascent" approaches to the optimal solution.

An example from transportation planning may help to explain this. Consider the case of a highway planner wishing to locate a new highway. Since he is also interested in the capacity to which it will be necessary to design the highway, it is not possible to model the problem by an analytical model. There are too many variables that can take on integral values; there are too many nonlinearities; and there are too many time-dependent variables for the present state of mathematical theory to handle. The planner would therefore build a simulation model of the system. To do so, he would assume that he knew where the highway was located and its capacity. He would then write a series of functions that would describe the traffic flow over time (these functions are based on empirically observed phenomena, perhaps coupled with theoretical queuing theory analysis). These enable him to predict how the highway in the proposed location and of the assumed capacity would respond over time, both in a physical and economic sense. The planner would then make adjustments to the location, capacities, etc., based upon the results of the study, and re-run the model to see if the economic response is better than the first study.

In this manner he could improve his design in a series of steps, making an "ascent" on the response surface. As it turns out, there are several different methods for achieving the hopefully-aimed-at "rate of steepest ascent." One such method is the use of repeated random samples of the capacity variables, the so-called Monte Carlo Method.

Many types of models, and in particular simulation models, rely on regression models as a primary analytic component. They are used in several of the models in the Steinitz-Rogers study (101.19). Basically, regression is a method to test hypotheses about a particular phenomenon against the observable and measurable effects of the phenomenon. Regression models allow one to make predictions about the behavior of one variable (the "dependent" variable) from observations of the behavior of another variable or group of variables (called the "independent" variables). In strict statistical terms, however, we are not allowed to assume causality between the independent variables and the dependent variable.

The final choice of the model to be used depends upon the nature of the systems to be modelled, the use to which the models are to be put, the sort of questions the planning problem poses, and the level of detail required of the analysis.

3. Single-Sector Models

There are now a substantial number of models having direct application to problems in land resource planning. Most of these are simulation models of single systems. Many, because they seek to show spatial changes, make use of data which are organized on the basis of a grid coordinate system. They are therefore theoretically capable of being interrelated as components of multiple sector models.

The business world and the military have for years been using mathematical models in their decision making processes. Mathematical representations of traffic systems and housing markets have also been used for several years in urban planning. Yet it is only recently that these methods have been more widely developed in land and resource planning. The lead in this application has come from hydrological studies, and in particular, studies of the effects of storms on river and waterway flooding.

a. Flow Systems

An example of a flow system model is that by Rogers, Russell and Sinton (101.10), in which storms are simulated over a land area. The model takes as its input the land conditions and periodic rainfall. It constructs the drainage paths from cell to cell on the base grid, the river location into which each cell drains, and the distance in cells to the point of inflow to the river. This distance can be modified by a time factor calculated along the specific path to the river and depending upon the slopes of the cells in that path. The amount of water which actually flows off each cell is also calculated as a function of the land and water conditions of that cell. This process enables the generation of flood hydrographs in the river. When this model is coupled with a simulation model which allocates development over time, it will be able to show how such development affects flooding conditions.

b. Growth Systems

Resource growth processes have also been modelled in a compatible manner. Gould and O'Regan (44), among others, have developed simulation models of forest growth and change over time. Their purpose was to model the decision making process of forest management for timbering. In their model, the landowner makes decisions and gives instructions to his "manager" (a computer program) which, following his instructions, calculates, records and returns the consequences of his timbering policy. The program thus can be used to evaluate alternative timbering policies over time.

c. Dispersion Systems

The dynamic character of many phenomena involves spatial dispersion or diffusion. Shepard (78), in his model of air pollution, presents a good example of the utility of this form of analysis. The model simulates the dispersion of the sulfur dioxide emitted from electric power generation plants in the St. Louis area under various atmospheric and wind conditions. Using this model it is possible to investigate the impact which a newly located plant would have on the level of sulfur dioxide pollution at any point in the St. Louis area. This type of model may also be analogously applied to consideration of the spread of plant diseases or the spread of pollution in a large water body.

d. Search Systems

Amidon and Elsner (4) of The Forest Service Research Center have developed a simple search procedure for determining the inter-visibility of points on a topographic surface. A similar procedure has been developed at the Laboratory for Computer Graphics and Spatial Analysis at Harvard [VIEWS (101.14)]. These systems permit the development of models which consider visual and scenic impact of development (such as housing and highw in a landscape. The procedures can be applied to any search procedures on three-dimensional surfaces, be they topography or conceptual fields, which exhibit the properties of a continuous surface.

4. Multiple Sector Models

Several sectorial models can interact in a more general planning system, with a common data system as the basis for the interaction. This could represent the hightest order of organization for analysis and prediction. The models would be considered components of the system, and themselves be capable of updating, improvement, or even rejection and substitution. The key advantage of this approach is that it begins to resemble a model with the necessary complexity to adequately replicate the real world of resource decision making. Thus the "What if...?" question can be asked in one o several controlled systems, and the evaluation can be traced through the resource base, in terms of its component subsystems.

In urban planning, there are now several years of experience in the development and use of multi-sector models. Several reviews have been made of models in use, notably by Kilbridge, Teplitz and O'Block (51), and Hester (46). In larger scale resource planning, however, the development of multiple sector models is a more recent activity.

An example of the multiple sector approach within one r-source area, forestry, is the study by Knode (52). Using a GRID data base, he has constructed and applied three interrelated models of forest growth: timbering, management and forest recreation. The model attempts to develop means by which land managers can identify and evaluate, over time, th financial and other consequences of policy alternatives in o-der to reduce the probability of activity conflict, while retaining the quality of the landscape and producing a satisfactory financial yield.

Another example, linking recreation and transportation models, can be seen in the Michigan RECSYS model (98). This computer based simulation model was designed with the goals o accurately predicting, quantitatively and by implication qua tively, the impact on the recreational experience of changes in either the condition of the resources themselves, the cha teristics of population demand, and/or the linkage system as represented by the transportation networks. The RECSYS simu tion model has three basic components: an origin model which describes the characteristics and county locations of the populations who will be the consumers of recreational activities a travel model which indicates the characteristics of the hig way network which allows the people to travel to places of recreation; and a destination model which describes the attractiveness of the State Parks of Michigan for camping and boating.

The development of multi-sector regional model was begun by Carl Steinitz, Peter Rogers, and others, in *A Simulation Model of Urbanization and Change* (101.19). It linked several evaluation models with several allocation models representing various types of urbanization pressures on the Boston Region:

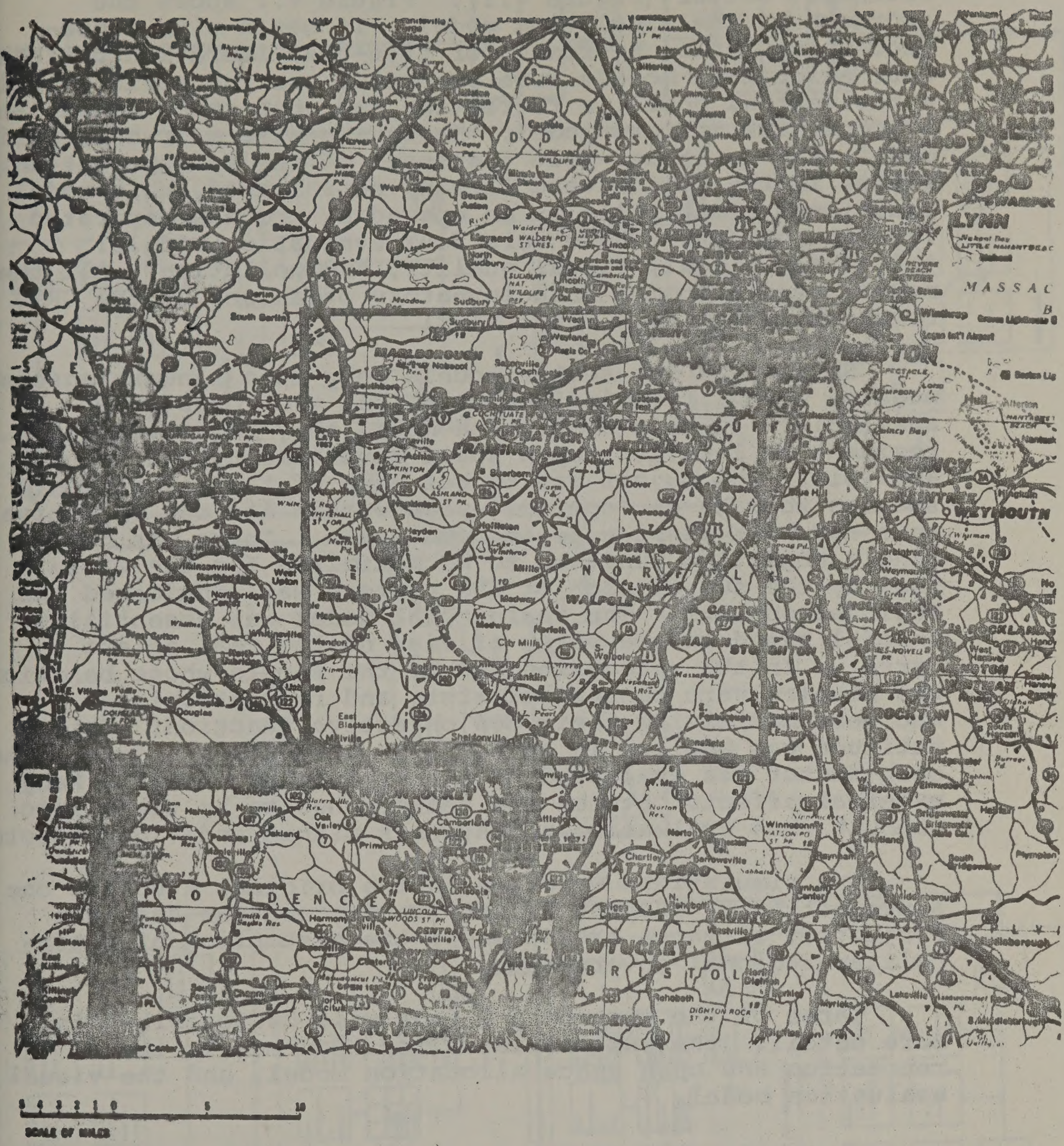


FIG. V.1
THE BOSTON REGION SOUTHWEST SECTOR
REGIONAL CONTEXT

Southwest Sector (Figure V.1). Figure V.2 shows the approach of the simulation model. It began with a projected population increase for five-year iteration periods. Four allocation models were prepared: an industrial model a residential model, a recreation and open space model, and a commercial centers model. There was also a transportation model, but as it was felt that most of the transportation routes in the region were already established, this model fundtioned principally as an upgrading process separated from the others. There were four evaluation models: political, fiscal, visual quality, and pollution. All the models used a common data inventory organized by the GRID computer system (See Chap. VI.F).

Several of the sector models rely upon linear regressio models, which, their drawbacks aside, are robust and available. In this simulation model they were used for residential location, open space development, and visual analysis. The object was to get each of the allocation sectors to make an "optimal" plan within its own objective sets and with respect to its own goals. There was no single objective function to be maximized for the whole region; the sum of each of the sectors was considered the regional optimum. The residential model was essentially a model based on the point of view of the real estate market. In the recreation model, the people whose behavior was modeled were conservationists and recreationists who were maximizing their own objective function. This attitude was applied in each of the allocation models. Then each sector was evaluated by the evaluation models. Many external effects between the sectors had to be taken into account when evaluating adjustments within individual sectors

Two simulations were run in the original studies, one a projection of current growth trends, and the second a projection of those trends under the assumption of metropolitan-regional government.

Three of the component models will be described in more detail: the residential allocation model, the recreation and open space allocation model, and the visual evaluation model.

The Residential Allocation Model

Jack Gaffney, Harry Parnass, Bruce White

The demand input to the residential location model was directly related to population increase. The distribution of housing types and the order of priority which various housing types would have in the event of a conflict for a piece of land were first established.

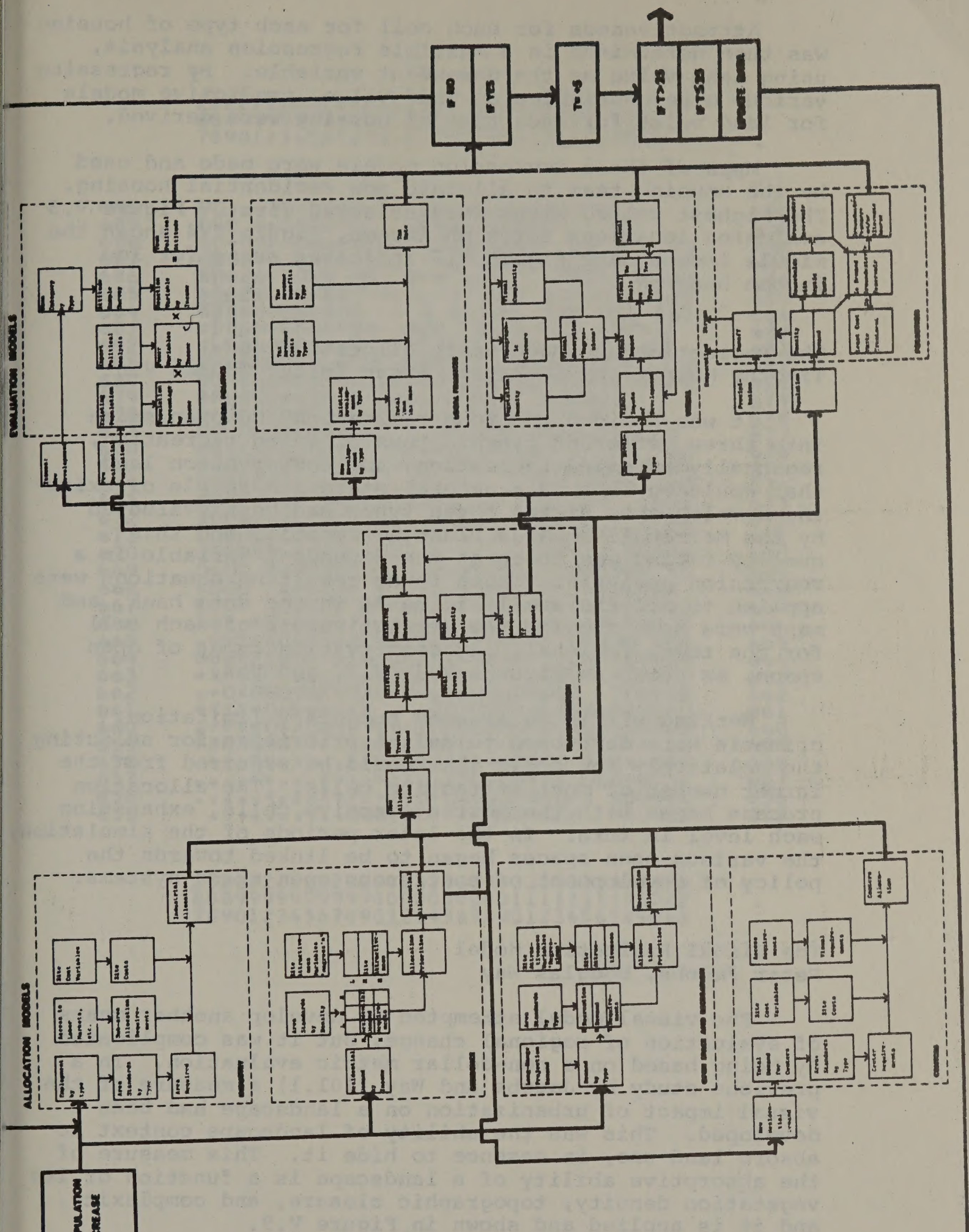


FIG. V.2
THE SIMULATION SYSTEM
(101.10, p. 7.)

Attractiveness for each cell for each type of housing was then determined in a multiple regression analysis, using land value as the dependent variable. By regressing various other variables on land value, predictive models for land value for each type of housing were derived.

Maps of these regression models were made and used by the housing team to allocate new residential housing. The highest valued sites were selected first. Figure V.3 evaluates locations for high income, Figure V.4 shows the middle income, and Figure V.5 indicates areas for low income housing

The Recreation and Open Space Allocation Model

Timothy Murray, David Gates, Susan Smith, Thomas Vint

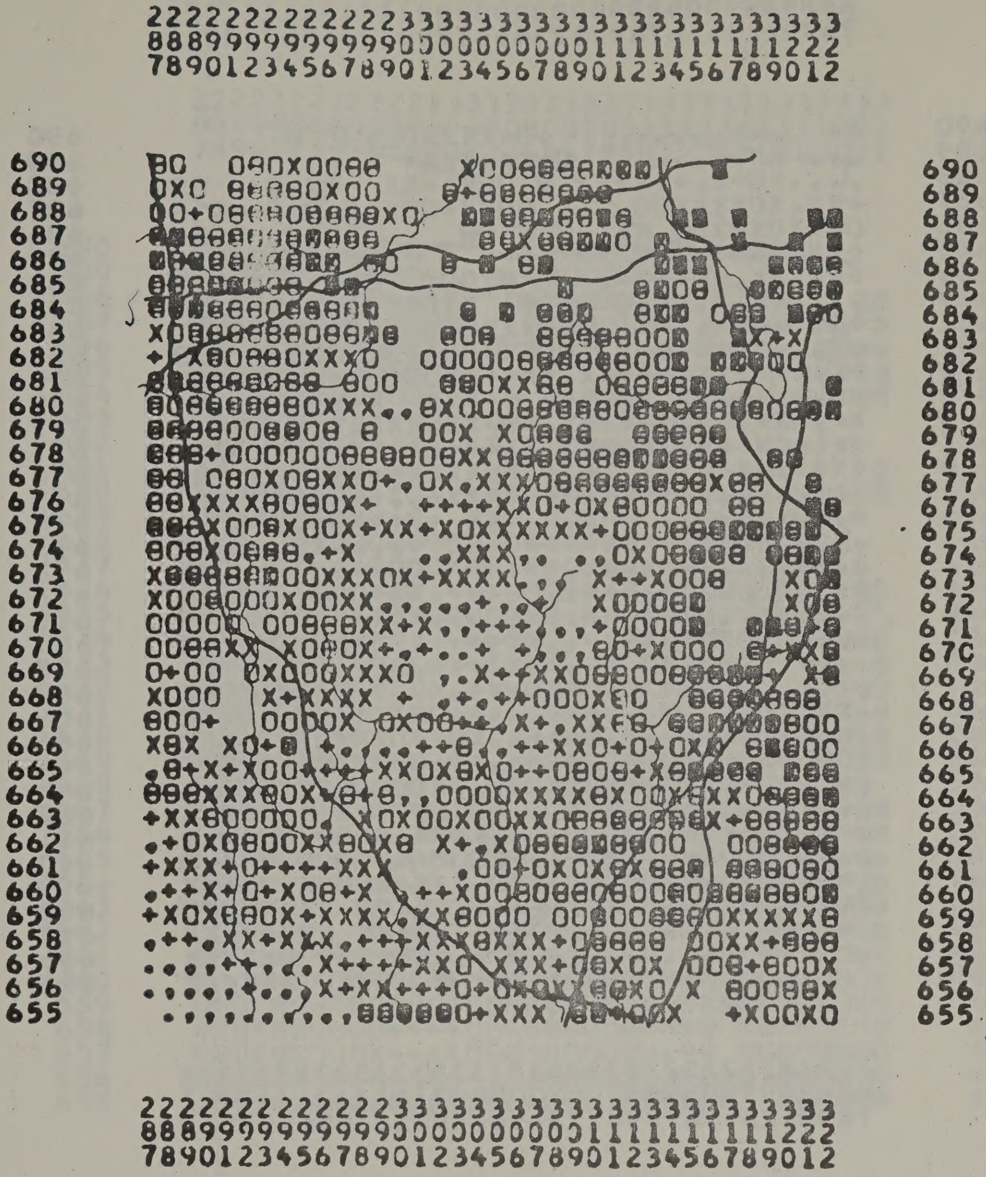
It was decided to group recreation and open space into three different types: town-oriented recreation, regionally-oriented recreation, and conservation land that would be left in a natural state. A sample of existing developments of the three types had been evaluated by the Metropolitan Area Planning Council, and this quality rating was taken as the dependent variable in a regression analysis. These three resulting equations were applied to all the available cells in the data bank, and maps were made showing the attractiveness of each cell for the town, regional, and conservation types of open space, as shown in Figures V.6, V.7, and V.8.

Working within an assumed budgetary limitation, criteria were developed to define priorities for selecting the relatively few cells that could be acquired from the larger number of most attractive cells. The allocation process began with the most attractive cells, exhausting each level in turn. In the later periods of the simulation, the various open spaces began to be linked towards the policy of development of continuous open space systems.

The Visual Evaluation Model

Peter Jacobs, Douglas Way

The visual model attempted to develop another means of evaluation of regional change, but it was complicated by being based on a non-dollar metric evaluation. In a previous study by Jacobs and Way (101.1) a measure of the visual impact of urbanization on a landscape had been developed. This was the ability of landscape context to absorb land use, in essence to hide it. This measure of the absorptive ability of a landscape is a function of its vegetation density, topographic closure, and complexity, and it is applied and shown in Figure V.9.



G. V.3
TRACTIVENESS FOR HIGH INCOME HOUSING
01.23, p.31.)

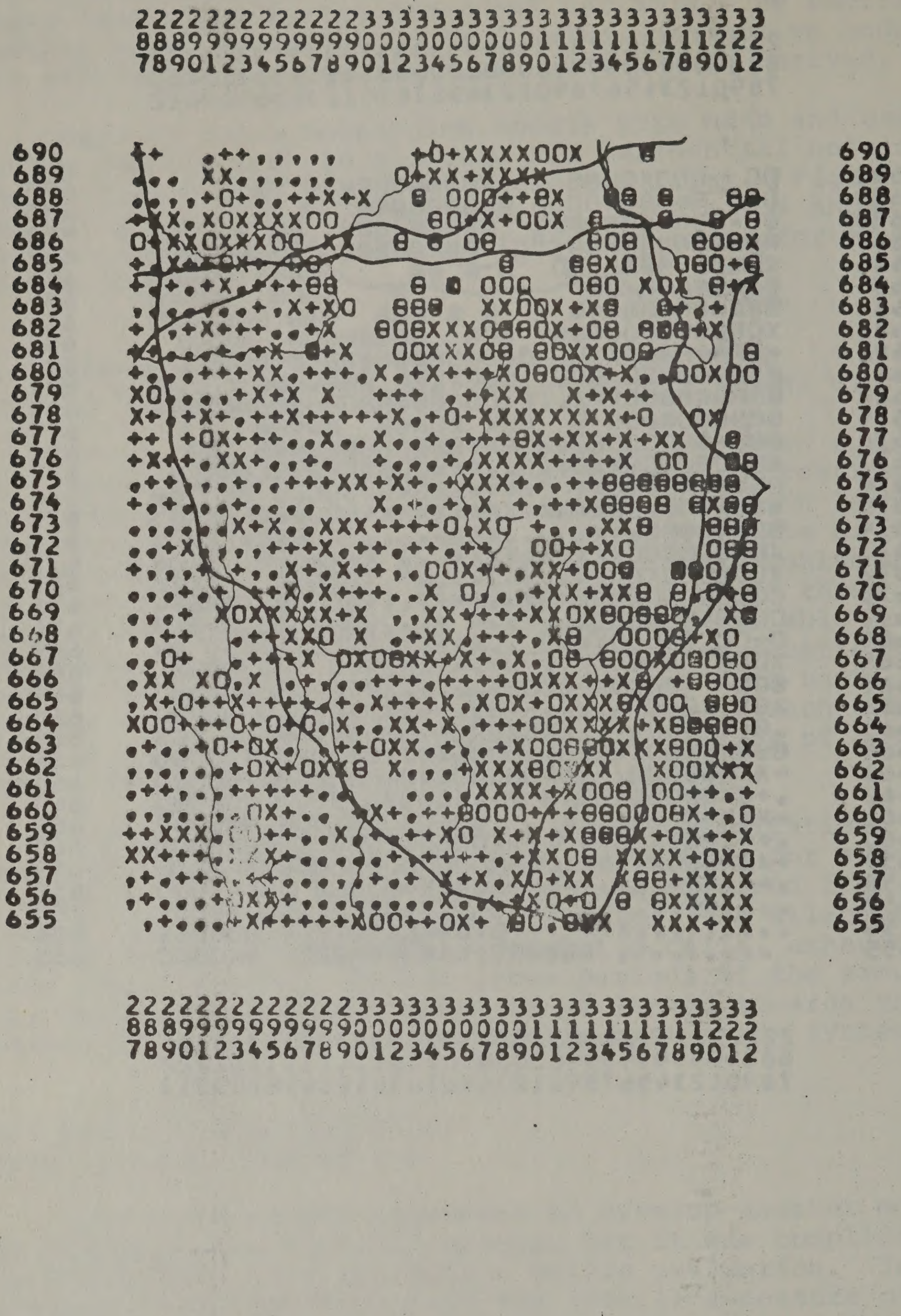


FIG. V.4
ATTRACTIVENESS FOR MEDIUM INCOME HOUSING
(101.23, p.32.)

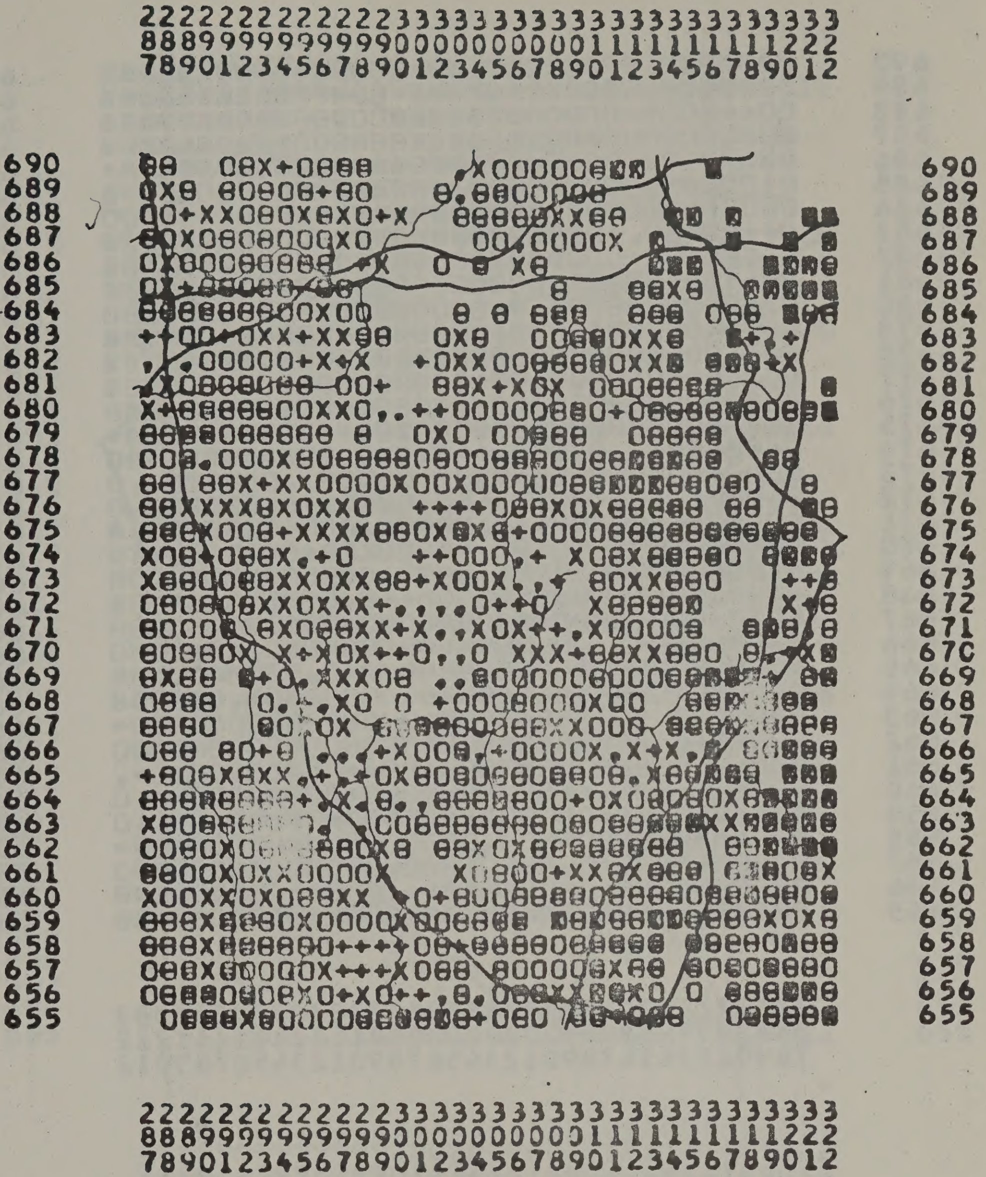


FIG. V.5
ATTRACTIVENESS FOR LOW INCOME HOUSING
(101.23, p.33.)

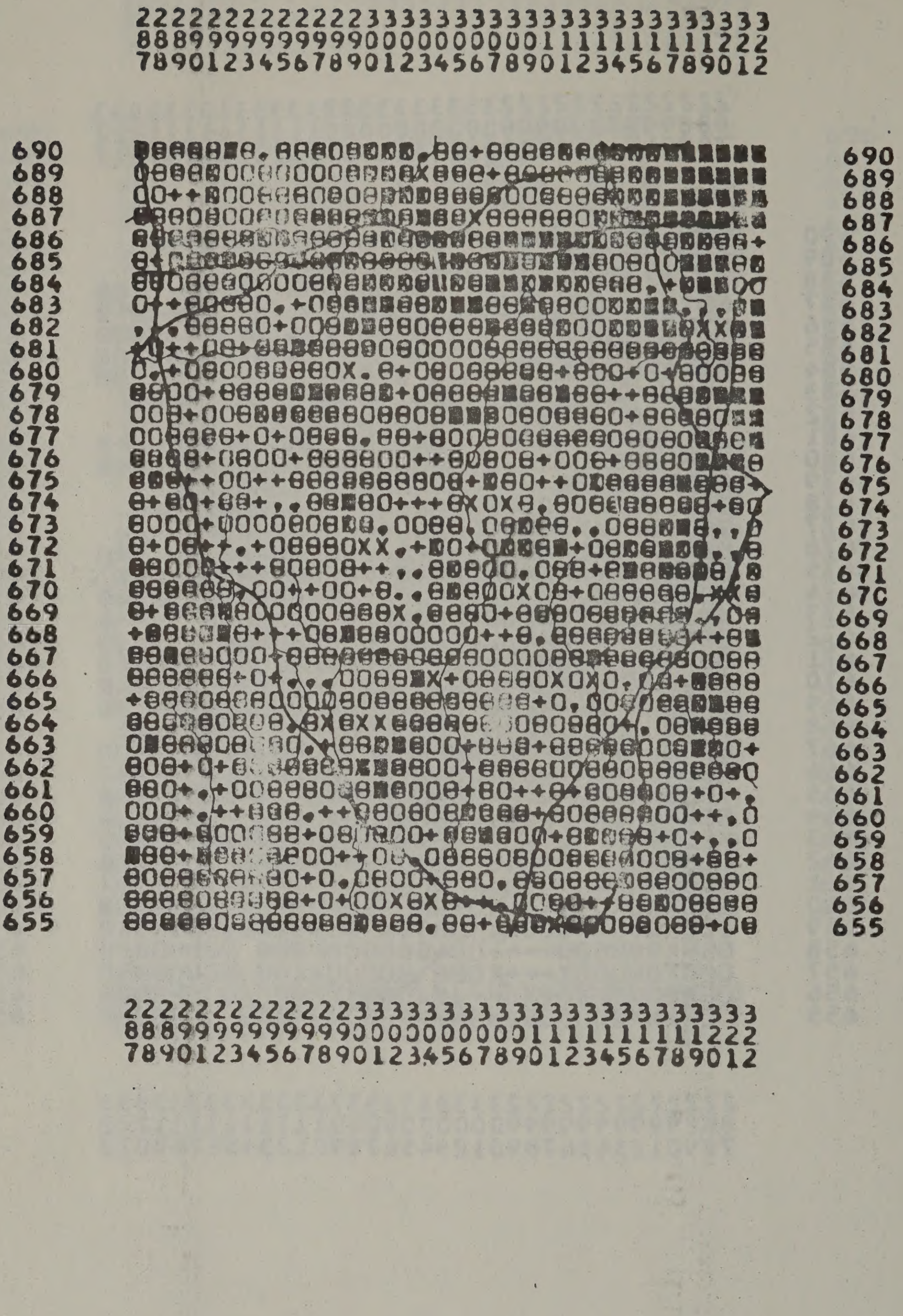


FIG. V.6
ATTRACTIVENESS FOR TOWN RECREATION
(101.23, p. 44.)

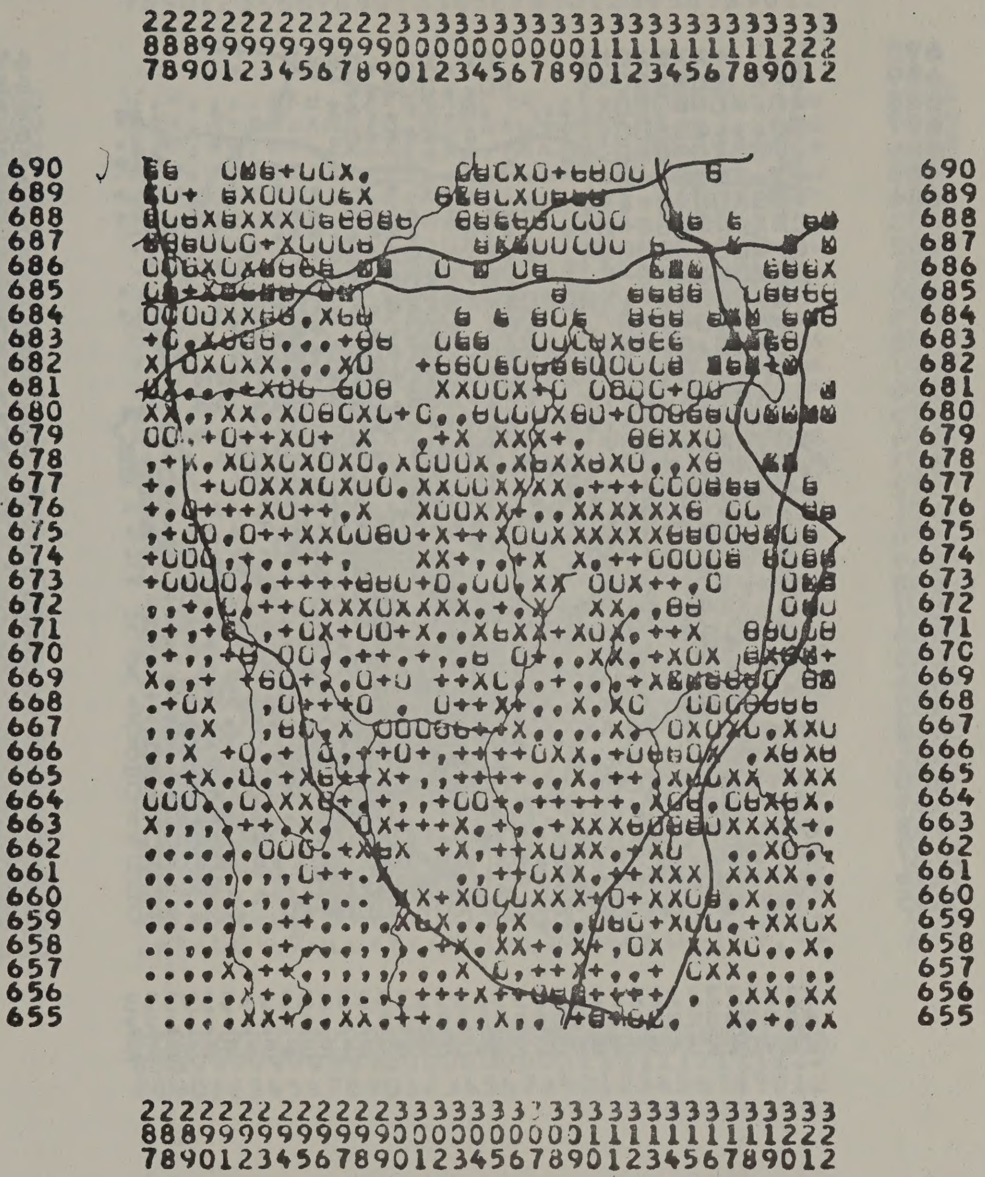


FIG. V.7
ATTRACTIVENESS FOR REGIONAL RECREATION
(101.23, p. 43.)

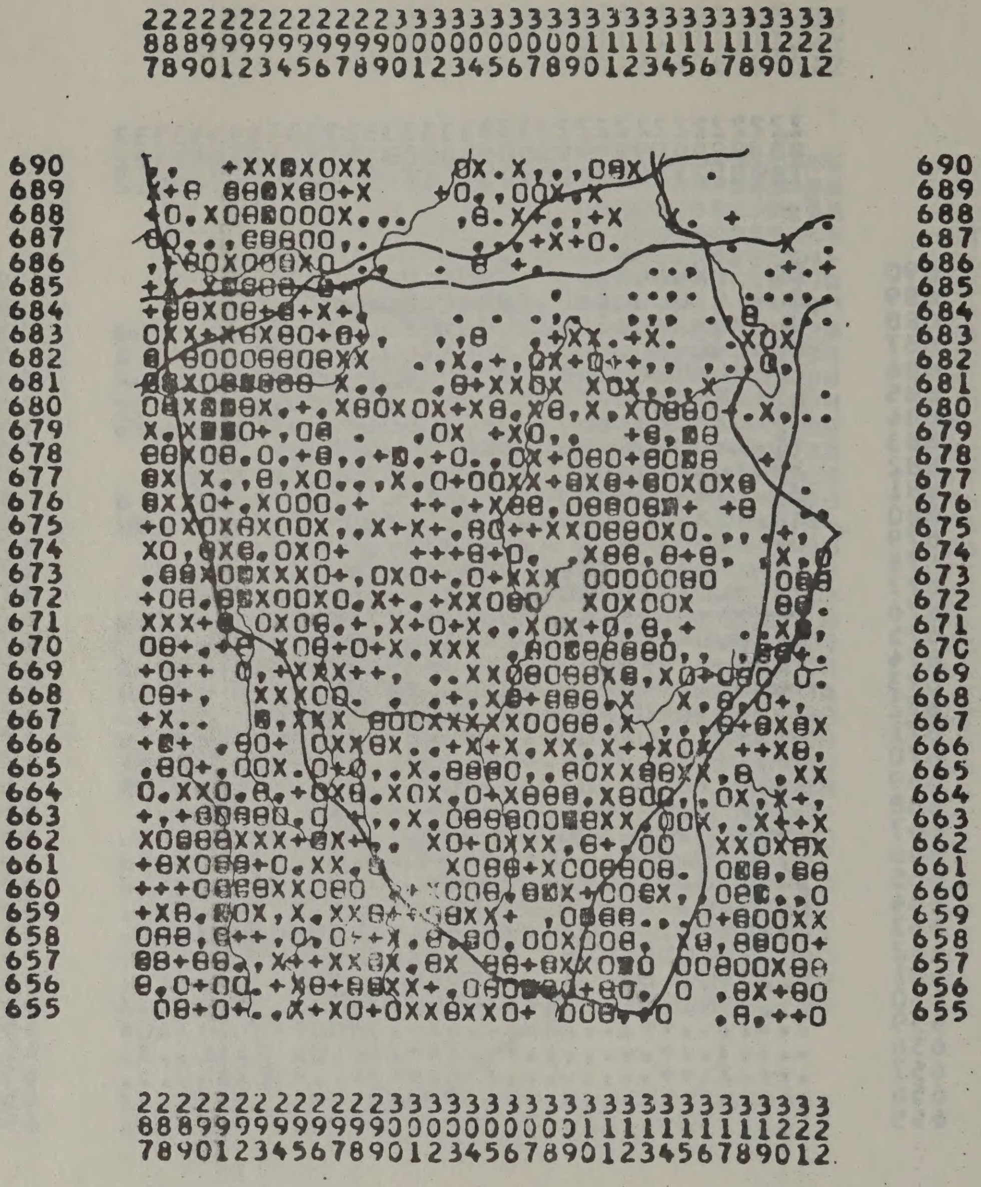


FIG. V.8
ATTRACTIVENESS FOR NATURAL OPEN SPACE
(101.23, p. 42.)

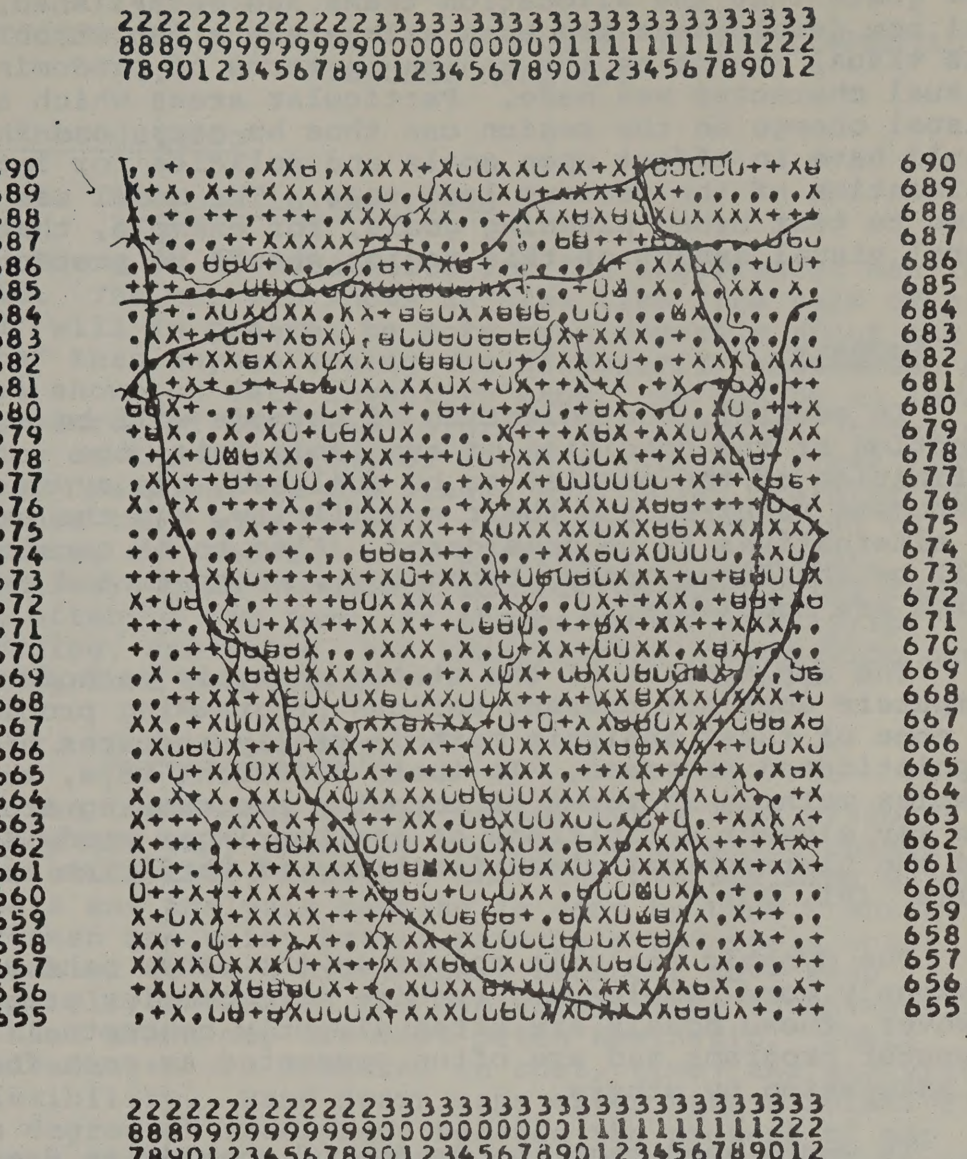


FIG. V.9
VISUAL ABSORPTION
(101.23, p.76.)

Land use inputs were recorded by location and then evaluated in the model for their visual impact relative to the goals that the allocation teams had established. When all new development had been allocated, a map which measured its visual impact on the region in terms of predominant visual character was made. Particular areas which assert visual change on the region can thus be seen, and this could have an effect upon goals and policies for later allocation of the various land uses. The model was thus used to test broad planning goals, for example, that the rural visual aspect of this region should be protected.

E. Summary

In general, the selection of methods will be a function of the condition of available data, the definition of the problem to be analyzed, the types of responses required and their specificity, and the variety of alternatives to be considered. Also to be considered will be the time, money, technology, manpower and expertise which are available.

The application of the static analysis methods to computers does not present serious programming problems, as none of these analysis methods really requires highly sophisticated programs. In their different ways, the most complex methods in terms of computer programming are the key element definitions of the Dearinger study (92), and the hierarchical classifications of Christian and Hills' (91, 93).

The dynamic analysis models on the other hand are obviously more complex and require more complex programming. However, these models are often directly conceptualized as computer programs and are often presented as such for use or adaptation by others.

It would seem that the degree of complexity demanded of computer programming is related to the degree of complexity of the methods themselves, many of which are simplifications of what are unquestionably highly complex and interrelated sets of systems. Indeed, many of the static methods purposely and necessarily attempt to make simplifications, as witness and many searches for an all-purpose, all-inclusive homogeneous data zone and a short list of key element variables. In no way does this search for simplicity reflect on the capabilities or qualities of the person carrying out the method. Rather, it reflects on the types of technology that their methods employ.

CHAPTER VI

TECHNOLOGY: THE USE OF COMPUTERS IN ENVIRONMENTAL RESOURCE ANALYSIS

A. Introduction

1. The Man in the Field

There is no substitute for the experienced man in the field. The man who knows an area like "the palm of his hand" will in general be more knowledgeable about the "data" than anyone seeing the necessarily abstracted patterns shown on data inventory maps. He can be an invaluable source of detailed information. However, total reliance on the expertise of field agents has clear limitations. Manpower is not always available, training and experience take long years, local experiences tend to dominate, and knowledge is difficult to transfer. It has thus always been necessary to rely on abstracted records, most often in map form, as the means of identifying, recording, analyzing, and transferring information concerning land resources.

2. Hand Drawn Maps

The technology of map-making has a long history, but methods are only recently undergoing dramatic change. It is still true, however, that the overwhelming majority of data and analysis mapping is done by hand. While draftsmen are using better materials and tools which are easier to work with, their products have been essentially unchanged for centuries. The advantages of the hand drawn map are most often aesthetic. Their disadvantages are measured in cost, time, and analytic inflexibility. Hand drawn maps often have a relatively high degree of inaccuracy because the process of map drawing is subject to constant simplification, in both the geometry of data zones and data scaling.

That hand drawn maps are useful in communication goes without saying. In analysis, however, they have limitations. Their most common use is as overlays. Even with the most modern map reproduction technology, be it color on plastic printing methods or photographic map superimposition, the number of maps and the number of variable levels which can be simultaneously analyzed rarely exceeds five maps and twenty levels. Furthermore, the procedures of making several maps of one analysis, or changing the graphic scaling to bring out particular aspects of the data, are rarely attempted. More importantly, it is difficult if not impossible to differentially weight the relative importance of the overlaid variables in an analysis.

3. Computers

The use of computers in resource analysis is a fairly recent development, as is their application to the production of maps and other graphic displays. One of the first of these applications was in the 1966 Delmarva Study by Steinitz et. al. (101.15).

Computer applications in resource analysis are most likely to be beneficial under any of the following conditions:

1. large numbers of data observations,
2. internal variability of data,
3. possible geographic expansion,
4. possible data variable expansion,
5. possible data updating,
6. flexibility in analytic procedures,
7. application of mathematical models,
8. repetitive analyses,over time,
9. high speed and low cost analysis, and
10. spatial accuracy and analytic precision.

A computer system for resource analysis will consist of four major component systems:

1. Input -- The provision of data in machine form,
2. Storage -- The filing system by which data are made accessible,
3. Manipulation -- The processing of data within the computer's memory according to predetermined rules, and
4. Output -- The display of the analysis in the form of tables, diagrams, maps, text, etc. The manipulated output is the reason for the existence of the system.

These represent the required capabilities for the stages in any analytic procedure, whether by hand or computer. In a computer system these subsystems must, in addition, be compatible with the computer equipment (hardware) and programs (software) with which the systems are constructed.

Computers differ greatly among manufacturers and models in capability, size, cost and availability. It is always difficult to specify the computer capability required for data processing, since programs have been written for small, medium, and large computers, However,it is safe to say that size will become more critical as the state of software programs advances. Increased file manipulation and statistical analyses prior to mapping, combined with more versatile display systems, will necessitate the use of larger more powerful equipment. Although several programs to produce computer maps have been written for the smaller computers (e.g., IBM 1401), more sophisticated and versatile programs require larger, more powerful and more expensive computers (e.g., IBM 360, CDC 3600).

B. Data Input

1. Preparation of Data in Machine Readable Form

There are three basic stages in the preparation of data input into machine readable form: the recording and/or keypunching of the data onto a medium which can be interpreted by the computer, the handling of that medium, and the long term storage of the original information.

The preparation of the data input is a time-consuming and often a costly process. However, once basic procedures have been established, many short cuts, simplifications and modifications can be devised to ease the heavy burden of the collection. In particular many short cuts can be found which involve collecting a set of information in a specialized manner and using a computer to convert it to the form in which the rest of data has been collected.

It is of the greatest importance to devise procedures that can be simply followed and do not require too much judgement on the part of the operating staff in the recording process. Quality control must be exercised at all stages of the preparation since having inaccurate and inconsistent data is often a far worse condition than having no data at all.

2. Recording and Keypunching

At this time, information about natural resources is primarily derived from either existing maps or black and white aerial photographs. This information must be converted from the visual form to a numerical form and recorded on a coding sheet. The numbers that have been recorded are then keypunched onto cards or tape. This two-step procedure is necessary as the different skills involved in interpreting and keypunching tend to be mutually incompatible.

The use of digitizing equipment to define the locations of points or boundaries eliminates the necessity of recording on paper the numeric codes and their consequent keypunching. In general, digitizing is a more efficient procedure; however it does require a higher level of sophistication especially with regard to the following aspects:

(a) The boundaries must be recorded on highly accurate drawings. The preparation of these drawings may be time-consuming and expensive.

(b) The digitizing hardware and recording equipment requires a reasonably high capital investment, which can only show a return with continued use.

(c) Experience has shown that unless highly skilled and very patient personnel are used, this procedure can generate errors which are time consuming to correct. In general this procedure will require a higher level of trained personnel than the simple procedure of separately recording numbers and keypunching them.

In a study with large amounts of data to be collected and an on-going process permitting the purchase of the necessary equipment and training of personnel, digitizing procedures will be efficient. For short term studies they will probably not be profitable.

Some advanced and sophisticated forms of remote sensing will record data directly in a machine readable form. Others prepare an original record such as a photo plate which can be scanned by a sensor to record the desired information. When using these forms of directly recorded information it should be realized that they often contain only an implied locational key. When this is the case, the data must be converted to a usable set of locational controls which are compatible with other information.

3. The Medium of Storage

Information can be recorded in machine readable form on a variety of media such as paper tape, punched cards, magnetic tape, specially coded forms for scanners, and electrosensitive numbers. Storage media must be chosen to be efficiently useable for the technology which is being used. Paper tape should not be considered for the storage of large data files as its two major problems, fragility and deterioration, create difficulties with important and costly data which far outweigh any of its advantages.

Punched cards are by far the most widely used form of creating machine readable information and they have been proven to work efficiently and easily. They are disadvantageous in that a large scale data bank will generate vast quantities of cards which are cumbersome to work with. In general, cards would be considered only the primary level of communication and in some cases they will be used only once, for recording the card images onto tape for further use.

Magnetic tapes are used for the storage of information, but they have not had a great deal of use in the past for the preparation of the data into a machine readable form. However, a series of new recording machines have been appearing over the past four or five years which can immediately transfer data to a tape and bypass punched cards. This procedure has the advantage that it eliminates the creation of the cards, which tend to be stored long after their useful life.

Specially coded forms and electrosensitive numbers have been devised for use with specialized reading machinery. This system requires a great deal of preparatory work for satisfactory results. It would, however, be an alternative to keypunching which might be attractive in conditions where keypunching costs are high and quantities of data are large.

4. Long-Term Preservation of Data

Data storage systems rely heavily on devices such as disc packs or drum files. These tend to be fragile, and a back-up system must be maintained which permits the re-establishment of data files which for some reason have been lost or damaged. The hierarchy of such a procedure usually takes the following form.

The active data, the data which are in regular use, would be frequently compared with a short term backup data file to check for any possible errors. This second file is usually stored on the same or a similar storage unit as the active data. A third long term back-up data file would be used in cases where a system failure destroyed both the active and short-term back-up files. It is also a wise procedure to check the short term back-up data at regular intervals. This third file should be stored on a unit that is not permanently resident on the operating system. Usually it will be on tape.

The ultimate back-up to a data system are the original data. However, when the original data are in the form of cards or specially coded sheets, these sources will deteriorate and may become totally useless over a long time period. Unless specific steps are taken to preserve original data such that they will in fact be usable for machine interpretation, it may be pointless to store them, as there is wasted space and effort involved with storing data. In the long run it is probably easier to duplicate all the information that is on cards or special sheets to magnetic tape, as a record of the original data.

Magnetic tapes can also deteriorate over time. If they are used as a medium of long term storage of original data, they should be checked at regular intervals for possible deterioration. The expected life of magnetic tapes is continually being expanded. Obviously, high quality tapes should be used.

C. Data Storage

1. Definitions

When describing data storage, several definitions must be made:

(a) A "word" of information refers to an elementary item of information (such as the X coordinate of a location or the type of forest at one location). A word stores one specific item of data.

(b) A "record" of information refers to a collection of words. These are processed and handled as a group and are referenced as a group. The important aspect of a record is that when it is referenced or used, all the information that is stored in the record as separate words is available for use at one time.

For efficient retrieval each record should include information that is required for processing at the same time, as it is very inefficient to have to read a file of records several times. When data are stored on cards, each card represents one record of information. However, one record can be defined as including several cards.

2. Types of Data Files

Electronic data processing procedures have demanded the development of sophisticated approaches to data file organization for applications in business and accounting. Dodd (35) presents a detailed description of each of the following three basic approaches to the systematic storage and retrieval of data:

(a) Sequential Organization: "wherein records are stored in positions relative to other records according to a specified sequence. To order the records in a sequence, one common attribute of the records is chosen."

(b) Random Data Organization: "Wherein records are stored and retrieved on the basis of a predictable relationship between the key of the record and the direct address of the location where the record is stored. The address is used when the record is stored and used again when the record is retrieved."

✓ (c) List Processing: "wherein the basic concept of the list is that pointers are used to divorce the logical organization from the physical organization. In a sequential organization the next logical record is also the next physical record. However, by including with each record a pointer to the next logical record, the logical and physical arrangement can be completely different."

The most commonly used approach in resource information systems is sequential processing. This is not because it is necessarily ideal for resource information but rather it is a result of the character of the technical skills and hardware required to use random access and list processing. These do not seem to have been available to most people working with resource information at this time.

3. Two Alternative Data File Structures

All spatial data has two basic attributes, a location and a value. When defining a real world or abstract space, the locational attribute is usually expressed in an x,y coordinate system and requires two values. However, using implied locations such as forest tract numbers, only one value is needed to define the location. For point data or gridded data, many data values are usually associated with one location. On the other hand, when dealing with areal data, one value is usually associated with many locations. These locations will usually refer to the points which define the boundary of the zone. These attributes of spatial data generate two basic alternative organization structures for the data.

Alternative No. 1 has data organized by category, with each record containing all the locations required to define the spatial extent of that data category and the data value to which the record refers. This type organization is referred to as a "category data file."

The principle uses of category data files have been with the storage of areal data which are described by the boundaries of zone sets, usually as a preliminary step to internal or implicit conversion to a grid. To handle zone boundaries it is almost impossible to use any system of organization other than a category file.

Alternative No. 2 has data organized by location, with each record containing all the data values for a specific location. Each record would contain one locational reference and many data values. This type of organization is referred to as a "locational data file."

Most operational resource information systems have been based on this second alternative. This is generally due to the methods of data collection that have been used rather than any technical efficiency. The types of spatial description methods that have been included in locational files are:

(a) Point Data -- As point data only requires one locational reference it is easy to organize on the basis of that location, and for most purposes this is the most efficient procedure to use.

(b) Pseudo Point Data -- In this case data have been collected at a point, usually the centroid of the zone, and are handled as point data. This introduces many problems such as the area of influence of the point, and the relationship of one point to the next, both of which may create statistical problems in analysis.

(c) Grid Data -- This is a special form of pseudo point data. However, since each grid cell refers to a constant area and has a constant relative location to its neighbor, this eliminates the two major uncertainties that exist with pseudo point data.

(d) Implied Location Data -- These data have no real locational organization and can only be referenced by a name tag which implies location. The only purpose of the name tag is to act as the locational organization structure of the data.

(e) Linear Data -- As linear data are usually associated with two locations, the beginning and the end of the line, it presents special problems. However, most efficient files of linear data are locational, and are organized on the basis of the position of line segments in a network hierarchy.

These alternatives, category data files and locational data files, represent two extremes of data organization. In fact, most operational systems will probably be some combination of the two procedures. As a general rule the form of spatial description which has been used to collect the data will determine the type of data file that is created in the initial stages. However, once the data have been stored they can be converted to another form if necessary.

✓It has been found that, when handling spatial data, the number of data values to be associated with locations usually remain constant. For example, a certain fixed number of land use categories, types of forests, or demographic variables will be recorded. Conversely the number of spatial descriptions that are required to locate any one of those categories is entirely variable. Four corners are all that are necessary to describe a rectangular forest tract, whereas it may require seventy corners to describe a highly irregular soil zone. The convenience of being able to use fixed length records with locational data files often discourages users from establishing category files which require a complex structure with records of different length.

At this time the initial procedures which require a minimum of sophisticated technical resources are the collection of areal resource information on the basis of a grid, and the organization of these data as a locational sequential file with fixed length records. While this currently represents the minimal combination of methods, it by no means represents the range of potentially applicable techniques, particularly as these are all undergoing constant improvement.

4. Grid Data Files

When handling areal data which are organized on the basis of a grid, the data files are structured in a locational sequential manner. Each record contains the information coded to a grid cell, and to retrieve a specific piece of information about a location, one first searches for the data record which refers to that location and then finds the specific piece of information which is desired. In normal processing, data cells are in exactly the same order in which they are required for processing, for example, by the GRID program.

When using a grid, a substantial amount of the data which are available will have been collected and displayed on the basis of spatial zones not necessarily those of the grid. These data must be used, recognizing that they are more apatially generalized than the cells of the grid data base. Rather than laboriously code all these data to each grid cell, they are organized as a series of seperate files. The grid data bank is the base data file and, through a series of indexes, each cell is linked to its source zone (i.e. census tract, watershed, etc.). The number of indexes is determined entirely by the number of diverse spatial zones from which data are derived. Data for these indexed zones are stored in separate "read" statements within the analysis programs. This technique saves a great deal of computer memory space and at the same time is highly efficient for the handling of the data.

D. Data Processing

Computer data processing techniques perform analyses and produce output at the scale of the data input, and precisely according to the criteria specified. There are no "fudge factors" (though there is considerable scope for producing analyses and graphic displays to meet predetermined requirements). It is in the processing stage that the computer can be a uniquely powerful analytic tool, as was discussed in the chapter on analysis methods. It must be emphasized however that the results of analysis done by the computer are only as good as the set of instructions given to the computer. Computers rarely make mistakes but programmers and analysts do, both in the logic of the programs they want to write and in the actual procedure of writing the programs. The precision that is required by the computer when analysis programs are written may well force new and more precise thinking, thus aiding in the search for new aolutions to problems in the analysis of natural resources.

The processing of input and storage files in order to produce output is divided into six basic operations: recording, classifying, sorting, calculating, summarizing, and communicating. The first three operations are carried out in preparing the input and storage files for the complex operations of calculating and summarizing the data.

1) Recording -- Data must be recorded in order to feed them into the computer system or to transfer them from one point in the system to another. [See the section on Data Input (VI.B.)]

2) Classifying -- Data are classified to identify like items for identical processing. They are usually coded by assigning numbers or symbols indicating the class or location to which they belong. [See Chapters III and IV for detailed discussions of the coding and locating of data]

3) Sorting -- The classified and coded data are then sorted by location or class codes to bring like items together in the sequence desired for efficient processing. [See Section VI.C on "Data Storage" for a discussion of the alternative methods of sorting and organizing data files.]

4) Calculating -- A most important function in data processing is calculation. Once supplied with data values for a given location, a computer is capable of performing a multitude of arithmetical and logical operations upon the data. Numeric data can be added, subtracted, multiplied, divided, exponentiated, square-rooted, factored, etc. These often create useful and otherwise unavailable new data as well as being the invaluable tools of precise analysis. In addition the computer, if appropriately programmed, is able to perform operations which use locational as well as quantitative data, including calculations based upon proximity or distance. For example, it is possible to obtain information regarding a given phenomenon within a specified radius from a point, or within the bounds of a specified area. Conversely, it is possible for the computer to determine the radius or area within which a criterion is satisfied. But whether the value mapped is one put into the computer or one derived by the computer, the resulting analysis is constructed on the basis of grid coordinate locations and numerical values associated with those coordinate locations. Exactly the same results can certainly be achieved by manual calculation. But a computer calculates more rapidly, economically and accurately than a man. For example, the complex process of interpolation and extrapolation performed by a large computer in producing a contour display by the SYMAP program (See Section VI.E) requires thousands of calculations per square foot of map. The operation is performed by the computer in less than a minute.

5) Summarizing -- Data and analyses are frequently summarized to facilitate handling and further analysis, or to provide new insights. In this way totals can be dealt with instead of voluminous details. It should be emphasized that too much detailed output is as useless as no output. Computation can generate hundreds of pages of output which will take days to read and study. If too much detail is created without summary, the important facts may be lost in a mass of numbers and irrelevant facts. The old proverbs of "the needle in the haystack" and "not seeing the forest through the trees" are very applicable when excessive detail has been generated by a computer. Summarization of the results must therefore be included in the data processing operations.

6) Communicating -- The last operation in the process of transferring data from the processing system to the output system is communication. This stage will be described in the next section of the report (VI.E).

E. Output -- Computer Graphics

1. Criteria for using computer graphics

Almost any conceivable map or display can now be prepared on a computer. However, not every map or display should be. In evaluating the possibilities of using computer mapping techniques for a given application, the characteristics of the maps desired and the characteristics of the data to be mapped must be considered. Applications most likely to benefit from the use of computer graphics have one or more of the following characteristics:

(a) a large number of maps for a given area which are needed at one time or will be needed on a recurring basis over a period of time;

(b) flexibility of size, content, scale, and data manipulation are important;

(c) uniformity of map appearance for many different types of data is desired;

(d) the time and cost required to prepare a number of maps is to be minimized;

(e) and highly accurate maps are needed.

These are common conditions when more complex and precise resource analysis methods are used.

Computer graphics output requires that the data being displayed exhibit a spatial dimension, either as geographic space on a map, statistical space as on a scatter diagram, graph, or bar chart, or three-dimensional space such as in architectural structures or conceptual surfaces. The subjects discussed in this report relate primarily to the display of data having a geographic dimension. Such data are particularly relevant to resource analysis because the spatial pattern of a given activity may be as significant as its magnitude. We are discussing, then, graphical representations for the spatial distribution of quantitative or qualitative data, i.e., maps.

Spatial patterns can be represented statically or dynamically. A static pattern is purely descriptive in that it represents a "snap shot" of a given phenomenon for a given time, for example, the distribution of forest density in 1969. Dynamic patterns are typically based upon time series data and portray changes or trends in terms of their direction, magnitude, extent, and/or rates of change. Obviously, the use of computer-generated displays can greatly enhance the ability of the analyst to identify and evaluate such dynamic patterns.

Computers can graphically display a wide variety of data and display them in two dimensions, as points, lines, tones, letters, numbers, symbols, or colors; in a third dimension, with heights above or below a standard plane or as surfaces in perspective or any other projection; or in four dimensions over time and motion, as in real time cathode ray tube, film or television displays. The actual choice of media will be a function of the human, machine, and fiscal resources available. Several comparative studies of output hardware and software combinations have been prepared, notably those by the Census Use Study (22), Goldstein Wertz, and Sweet (43), and the Laboratory for Computer Graphics and Spatial Analysis, Harvard Graduate School of Design (101.21).

2. Output Hardware

Any of the many available computer output devices can produce graphics in some form. However, the appearance of these graphics as well as their accessibility and equipment cost varies a great deal. The basic types of output equipment are mechanical or cathode ray tube plotters, and line printers.

(a) Plotters -- There are two types of plotters: mechanical plotters, operating either on a drum or a flatbed, and electronic plotters utilizing cathode ray tubes for image generation. Their image is transferred through exposure to film or photosensitive paper which must then be developed to obtain hard copy. Hard copy, as opposed to soft copy, is permanent in nature. Plotter operations are either incremental (digital control, digital drive) or digital to analog (digital control, analog drive). Incremental plotters respond to a set of computer instructions which call for the printing of a small line segment. Digital-to-analog plotters draw entire lines at a time by converting digital data to analog signals.

Mechanical plotters are the slowest but least expensive plotters. Flatbed plotters utilize pens which are moved over stationary paper to draw the map. They may have large, but fixed surface areas for mapping. Drum plotters move the pen in one direction and rotate the paper on a drum perpendicular to the direction of the pen movement. Plots can thus be of long dimension in one direction, but only a portion of the plot can be viewed at one time. Mechanical plotters have the ability to produce multicolored displays if the map is drawn in stages and the pen is changed to provide new colors.

CRT plotters construct a plot or drawing very rapidly. However, CRT plotters have small (up to 11 x 17 inches) drawing surface areas available. Larger plots eithe call for enlarged film images or spliced murals. Enlargemen are generally unfeasible because of distortion or poor resolution, and splicing smaller sheets into a mural is tedious and time consuming.

Geo space plotters made by the Geo Space Corporation of Houston, consist of a camera device which moves along a track perpendicular to the surface of a cylindrical drum. The recording medium, either film or photosensitive paper, is wrapped around the drum. The drum is 40 inch wide and can hold a sheet 60 inches long. The action of the camera is synchronized with the drum rotation, and a 4 x 60-inch strip is plotted with each drum revolution. Ten revolutions will result in a 40 x 60-inch plot.

In general plotters are capable of providing very precise and attractive output although such devices are not yet available at every computer installation. Their cost as well as the relatively infrequent use of this kind of equipment accounts for their limited availability at the present time.

CRT devices are likely to become more widely used, lower in cost than at present, and well provided with software for mapping. Their increased use will be justified by their great advantage in allowing the user to communicate directly with the computer, permitting him to actually alter the image displayed and thus rapidly evaluate alternative displays. Their usefulness will undoubtedly become widespread, especially when they are coupled with devices which can print on paper the image shown on the CRT screen. The technology already exists, as the military have been using CRT systems for several years, but nonmilitary experience has been slight. Most users are unlikely to have the opportunity to become experienced in the use of CRT systems for graphic display purposes until their cost lowers.

(b) Printers -- There are two basic types of printers. Character printers resemble typewriters, printing one character at a stroke. Line printers are substantially faster, printing one line up to 140 characters as a stroke, and 10 strokes per second.

Line printers are a necessary part of almost every computer installation. The ubiquity of the line printer makes it a convenient and economical output device for producing computer maps. Although widely available at low cost, line printers have definite limitation in the appearance of the output of which they are capable. One reason for this is that although line printers are able to produce a wide variety of computer output, they were not originally designed to print maps or other graphic displays. As a result, they cannot draw continuous lines, but may be used to roughly approximate line drawings by a series of print characters. In addition, a map prepared in this manner can represent the location of a point with a precision of only ±1/2 the size of a print character. As a result, line printers are less suited than plotters for displaying line drawings; their lines may be accurately shown, but they are not precise.

In the case of zone or area symbolism, which is the most necessary output for resource analysis, line printers are capable of providing a suitable end product, and in some ways a superior one to that produced by line plotters. Although the only characters available for use are those which appear on a given print chain, overprinting provides a wealth of possible symbols and tones. In addition, it is possible to obtain special print chains prepared with symbols more appropriate to graphic display. Printer programs are also available to generate plates for the offset printing of colored map displays.

Since line printers are designed to print alphabetic and numeric characters, they are obviously capable of printing words and numbers anywhere on the map surface. The letters are always printed horizontal to the page, just as they are on a typed page.

In sum, the line printer's graphic assets include the ability to produce patterns or tones over areas, fast operating speed, wide availability and low cost.

3. Software

Computer programs for producing maps and other graphic displays are usually written for a particular type of output device -- such as a CRT, pen plotter or printer. In all cases, the precision or "grain" of the graphic output is a function of the output device, not of the program used to instruct the computer in its calculations.

(a) Plotter Programs -- The comparative limited use of line plotters accounts for the scarcity of plotter programs as well as the special purpose nature of most existing programs. Mapping programs have been prepared by various agencies of the U.S. Government, the Department of Geography at the University of Michigan (74), the Puget Sound Regional Transportation Study (24), the Systems Development Corporation (23) (as part of the SPAN computer system), and by the staff and others at the Laboratory for Computer Graphics and Spatial Analysis, Harvard University, [OTOROL, SYMVU, and OBLIX, (101.21)].

Programs for plotters are characteristically designed to locate precise values at precise locations. There are, for example, plotter programs which will reconstruct the features of a base map stored on tape, drawing such items of locational data as street names, streets, railroads, rivers, topographic contours, or property lines. In addition, quantitative data values may be added.

A pen plotter can, by drawing the great number of lines necessary for the task, be made to shade zones or the contour line levels with symbols chosen to reflect a transition from a high to low value range, as with a gray scale, but the time required to do so substantially increases the cost of the map.

CRT plotters, devices which draw with a beam of light on photosensitive paper or film, operate with such speed that the addition of shading or other supplemental symbolism to a map prepared by this method does not require a significant amount of time beyond that required for the basic line map.

In summary, programs prepared for plotting devices can generally by used on either a pen plotter or, with minor modifications, on a cathode ray tube plotter. Plotter programs in general are capable of providing very precise and aesthetically pleasing output, but at greater cost than by other means. Therefore, plotter equipment and programs are sometimes the best choice for preparing a small number of maps for use in publications or public display, but not for preparing numerous maps rapidly in the course of a study.

(b) Printer Programs -- Rather than locating values precisely at any point on a map, printer programs locate standard print symbols and combinations thereof at pre-established print positions. At first glance, this may seem a severely limiting condition, but for most applications, particularly those in large and complex resource analyses, the printer is a desirable choice because of its speed, its widespread use at almost every computer installation and its low operating cost. It is not surprising, therefore, that there are a variety of mapping programs which print, rather than plot, the output. Among these are:

(1) MAP 01, by the New York State Department of Public Works (14);

(2) MIADS, by the U.S. Forest Service Research Station at Berkeley (3);

(3) SYMAP, by H.T. Fisher and others at Northwestern University and at the

Laboratory for Computer Graphics and Spatial Analysis at Harvard University (101.21);

(4) GRID, by D. Sinton and C. Steinitz at the Laboratory for Computer Graphics and Spatial Analysis at Harvard University (101.12, 101.21).

In summary, computer mapping programs written for line printers offer the user significant advantages of speed, economy, and flexibility, whereas maps produced by plotter programs and equipment are usually superior in their linear precision and aesthetic appearance.

The initial development of a computer mapping system could benefit from the use of a printer mapping program. By doing so, the user would be able to explore a wide variety of computer applications at the lowest possible cost. In most instances, the flexibility of the mapping program is of the essence: flexibility in meeting a wide range of possible applications, in data requirements, and in the kinds of maps which the program is capable of producing. On the other hand, the design of a computer mapping system should also reflect the desirability of being able to use the CRT devices, plotters and printers with a minimum amount of modification.

In any case, a graphic system should reflect the needs of the user rather than the capabilities of any specific type of hardware, existing or proposed. The system should be as machine independent as possible, being capable of use with equipment currently in widespread use as well as other devices which are likely to be widely used in the future. Machine independency is also important for the future of the system because of the rapid rate at which new computer equipment becomes available and existing devices become obsolete. Designing a system which can be used with a variety of output devices will make it possible to make flexible use of those devices which are most appropriate for any given purpose and within given resources.

F. The Grid Program

GRID is a computer program created in 1967 by Messrs. Sinton and Steinitz specifically to provide a highly efficient means for the handling and the graphic display of large quantities of information collected on the basis of a rectangular coordinate grid. It is designed for line printer output and has also been interfaced with a variety of plotter output programs, thus making it useful for most of the currently available output hardware types. It is also available in a teletype version, making it applicable for low cost on-line use. The program is written in FORTRAN IV and is currently being operated on an IBM 7094 with a 32k memory, or an IBM 360/65 using 120k byte mempry. With some internal adjustments, it can be run on a computer with a memory as small as 12k words.

The program requires two sets of data input -- first, the data values associated with a spatial grid, and second, a series of instructions to the program about the particular procedures and forms that are towbe used for analysis and display.

Each data value is assumed to be associated with a cell on the grid. It is essential that the values should be processed in the correct order, since the program accepts the data in the order in which it prints the maps. By the standardized printing process, the program starts at the top of the map and processes the data horizontally, row by row, and from left to right in each row. The numbers below represent the order in which 30 data values in a six by five grid will be printed and processed.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30

The user specifies the size and the shape of his grid. While the program is normally used in rectangular grids, it provides two methods of specifying irregular outlines. The program has been designed with an internal loop that permits an unlimited number of cells to be mapped. However, in normal usage, it is not expected that the average grid will be greater than 10,000 data points.

While the program is designed for use by persons with very little programming experience, it is necessary for the user to specify his own data format in a subroutine called FLEXIN. Since the program is designed for general use on a variety of data sources, it was felt that it is easier for diverse users to write their own input-output formats and not be constrained by fixed formats internally specified within the program. Before printing the spatial or map diagram, the actual data values are generalized into groups, each group having a unique graphic symbol associated with it. Using options, the user can then specify the number of levels, the maximum value of the data, the minimum value of the data, and the relative size of each of the levels in the range of the data. Thus, the user has complete control over the levels into which his data are divided. The user also has control over the symbolism which is used to print the spatial diagram, e.g., a gray scale between white and black, a dot map, or any alphanumeric symbols. The program will also print specified information about the data analyses which are being mapped, and it will print the numbers of the grid coordinate system around the edges of the map.

The function of the GRID program is to provide a graphic output capability within a modular system of programs which are being developed for the analysis of resource information. It does not contain any analysis capability of its own beyond the determination of frequency distributions within the levels. However the system does accommodate such standard statistical procedures as multiple regression analyses. It has been found that in most cases it is wiser to write a program which is designed to solve a specific problem rather than to force a new problem into the form that is necessary for a program which has previously been created.

Previously developed analysis programs which have used the GRID program are available for reference and, where proper, for use. Applications have been made in a wide range of land use allocation models, and a variety of evaluation models [For example, see Chapter V, Appendices A and B, and (101.19)].

The program has also been interfaced with a variety of analysis programs, notably two programs which have been developed to examine relative location on topographic surfaces:

VIEWS (101.14), a program to determine which locations can be seen from a specified location.

FLOWS (101.14), a program to determine a water flow pattern within study area by connecting the grid cells on the basis of elevation and slope.

The program has also been interfaced with a variety of graphic output programs for use on plotters. These include:

SYMVU (101.21) and OBLIX (83), which provide oblique views in a variety of projections of contour or topographic surfaces, and OTOTROL (101.21), which provides the capability for drawing pre-specified three-dimensional forms in perspective.

A version of GRID, TELE-GRID (101.21) has been developed for use on teletype terminals, thus affording a low cost on-lone computer link.

G. Computer Graphics

The following figures show typical line printer output of the GRID program and line plotter output of the programs with which GRID is currently interfaced.

FIG. VI.1 - GRID; one symbol format; number symbolism with overlay.

FIG. VI.2 - GRID; one symbol format; tone symbolism with overlay.

FIG. VI.3 - GRID with INDEX; one symbol format; tone symbolism with overlay.

FIG. VI.4 - GRID with INDEX; one symbol format; tone symbolism with overlay.

FIG. VI.5 - SYMAP with GRID data systems; 1/2" x 1/2" format; tone and number symbolism.

FIG. VI.6 - GRID; 1/2" x 1/2" format; keyed tone and number symbolism.

FIG. VI.7 - GRID; 1/2" x 1/2" format; tone and number symbolism with overlay.

FIG. VI.8 - GRID with VIEWS; one symbol format; keyed symbolism.

FIG. VI.9 - GRID with FLOWS; one symbol format, keyed symbolism.

FIG. VI.10 - TELE-GRID;1/2" x 1/2" format; tone symbolis.

FIG. VI.11 - CAMAP; one symbol format; color symbolism; Color plates produced by separate printouts of different value levels are a capability of most line printer programs, including GRD.

FIG. VI.12 - SYMVU with GRID data system.

FIG. VI.13 - SYMVU with GRID data system.

FIG. VI.14 - OBLIX with GRID data system.

FIG. VI.15 - OTOTROL with GRID data system.
(A-E)

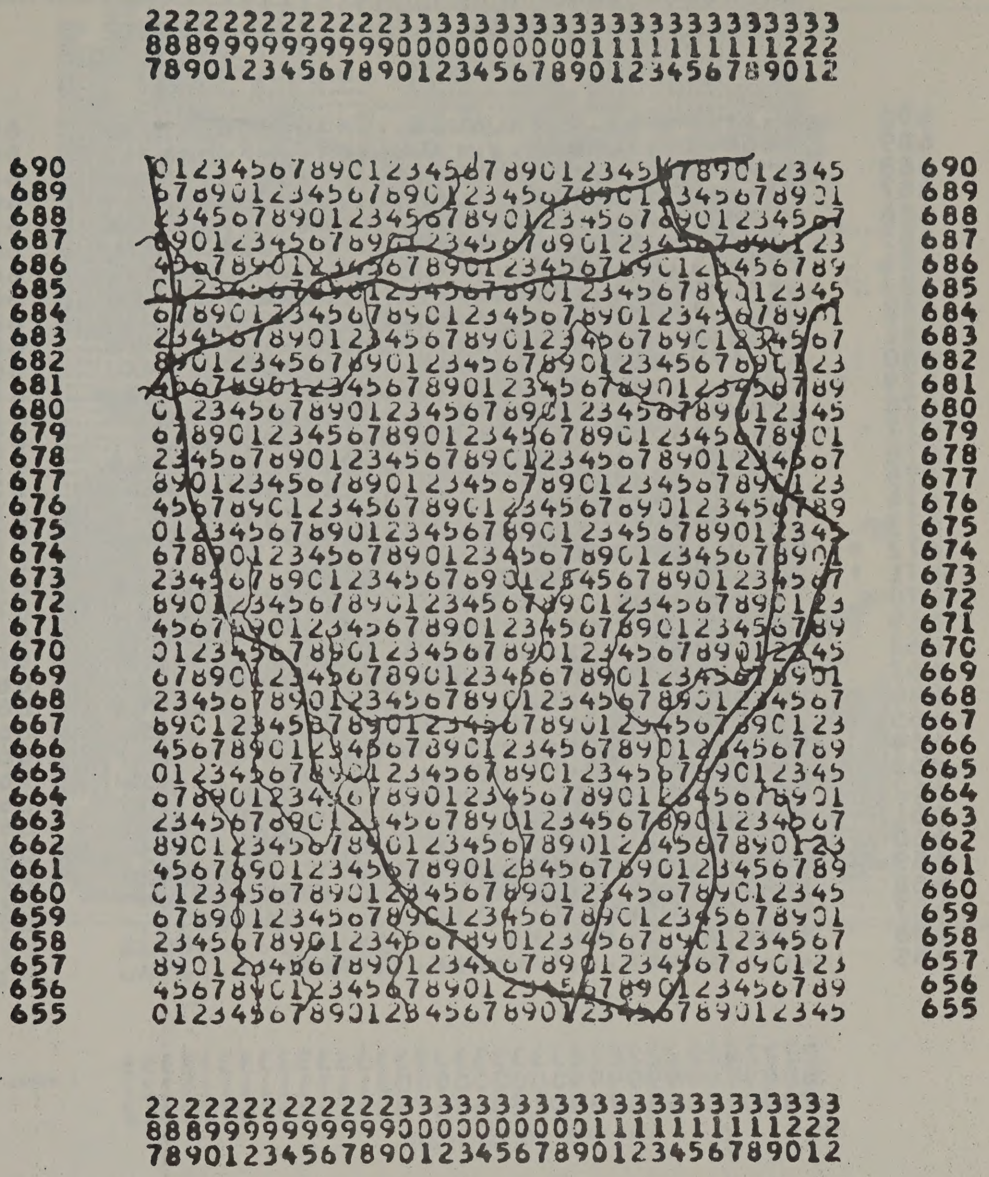


FIG. VI.1
GRID
One Symbol Format; Number Symbolism
With Overlay
(101.23, p. 10.)

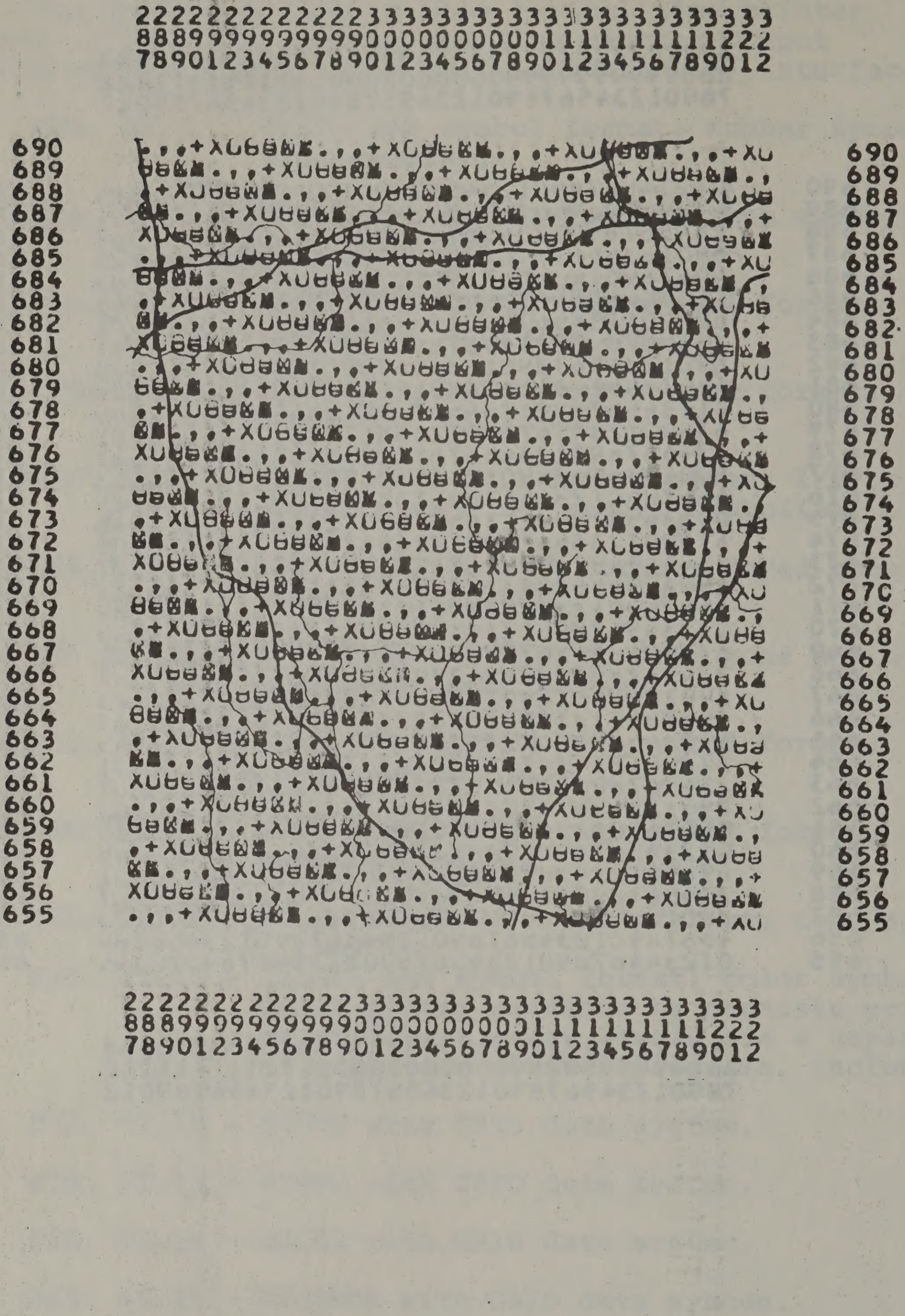
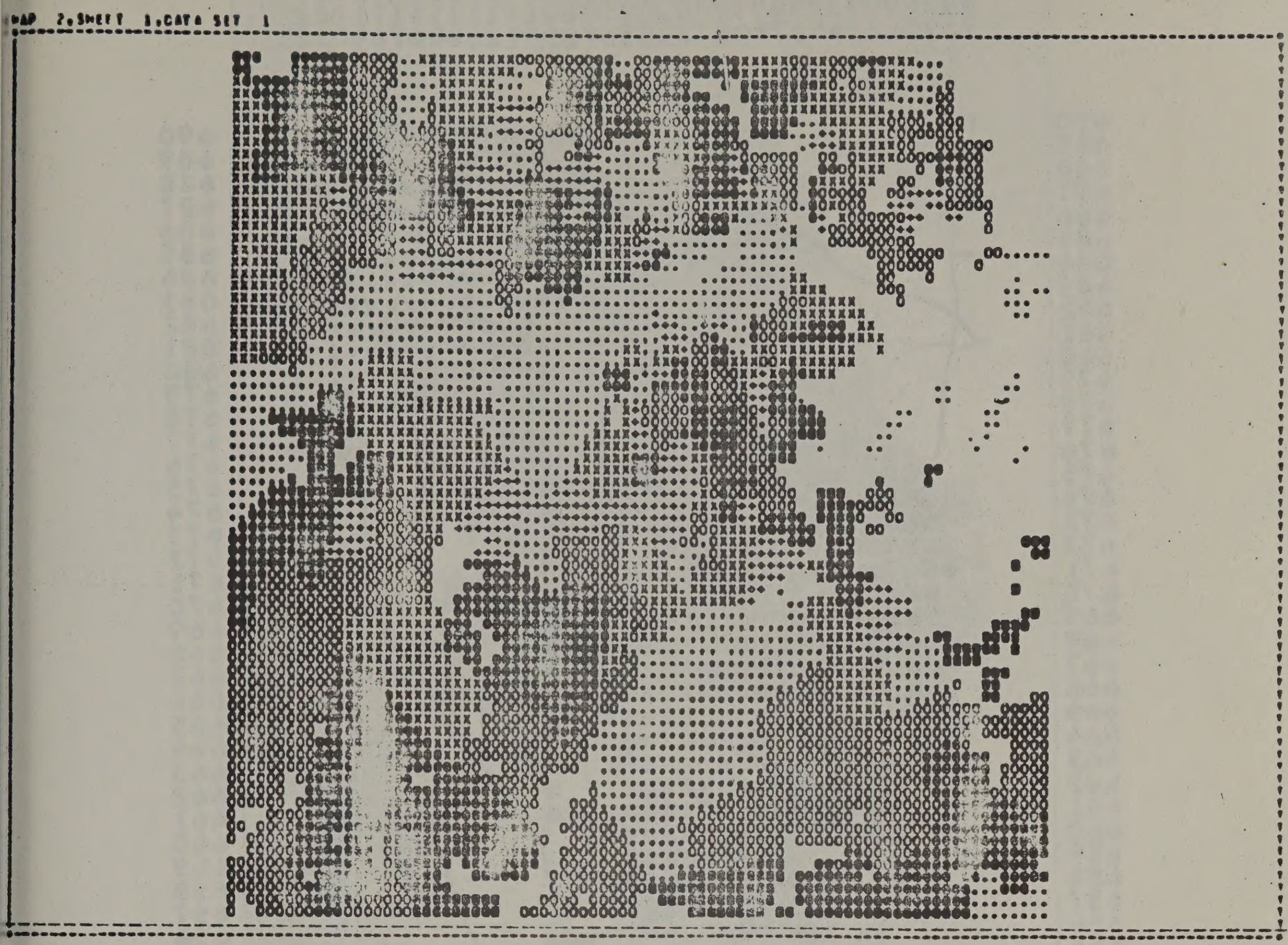
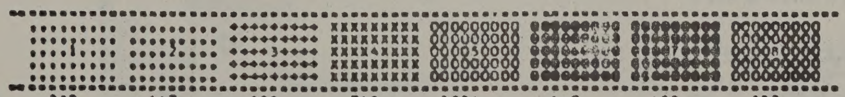


FIG. VI.2
GRID
One Symbol Format; Tone Symbolism
With Overlay
(101.23, p. 11.)



```
BOSTON METROPOLITAN CORE


PERCENT POPULATION UNDER 5

                                        DATA BY CENSUS TRACT 1960
                                        BOB ERICKSON

DATA MAPPED IN  8 LEVELS BETWEEN EXTREME VALUES OF      6.00 AND     14.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
   ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)
      MINIMUM        6.00     7.00     8.00     9.00    10.00    11.00    12.00    13.00
      MAXIMUM        7.00     8.00     9.00    10.00    11.00    12.00    13.00    14.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
      MINIMUM       12.50    12.50    12.50    12.50    12.50    12.50    12.50    12.50

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
      LEVEL           0        1        2        3        4        5        6        7
```



```
      FREQUENCY     282      447      328      765     1056      449      632      352
```

FIG. VI.3
GRID WITH INDEX
One symbol format;
tone symbolism

[From Department of Landscape Architecture, Harvard Graduate School of Design, Boston Metropolitan Core Study, 1968.]

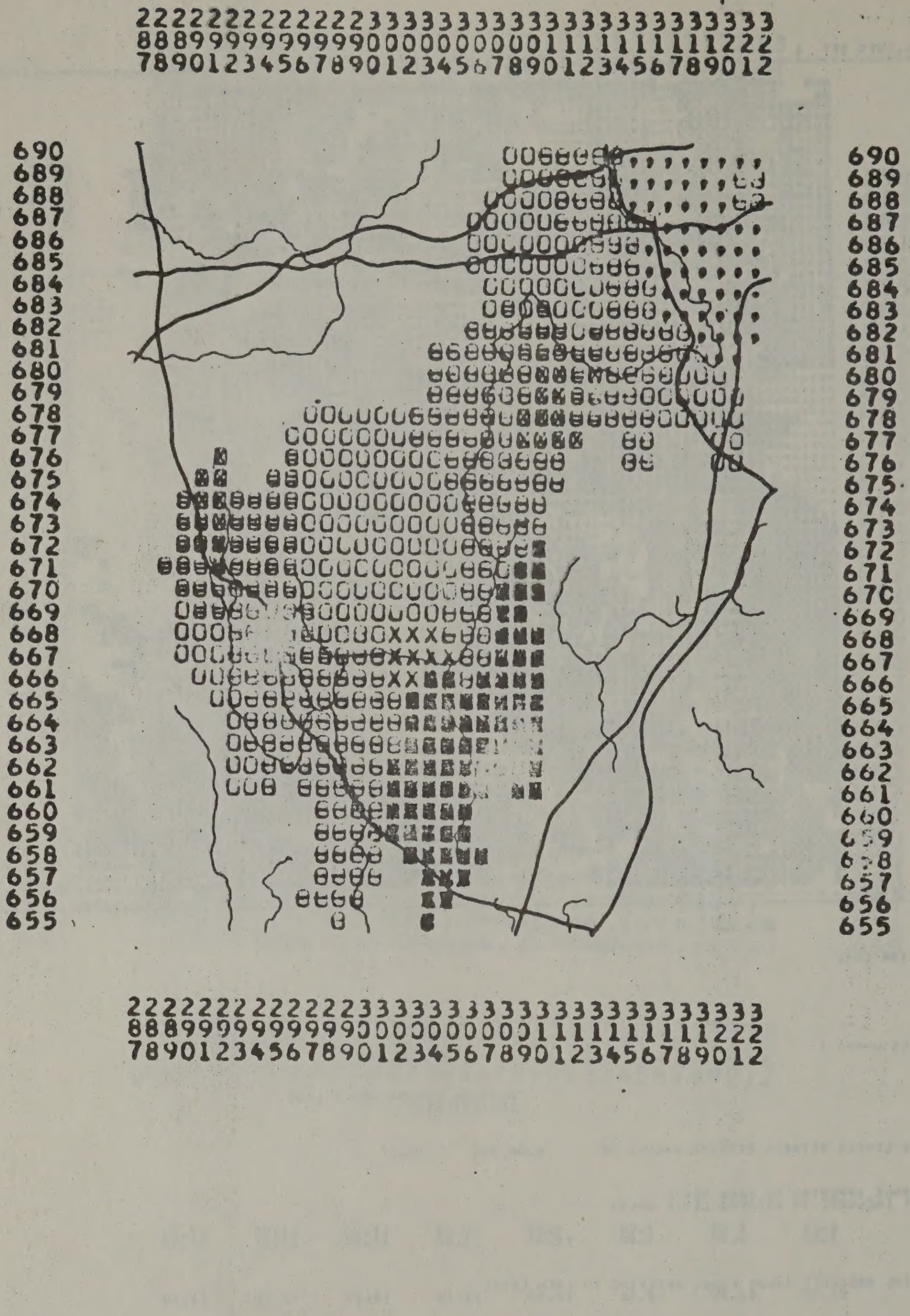


FIG. VI.4
RECREATION POTENTIAL OF
SUB-WATERSHEDS IN THE
CHARLES RIVER BASIN
(92, 101.23, p. 131.)

GRID WITH INDEX; One Symbol Format
Tone Symbolism With Overlay

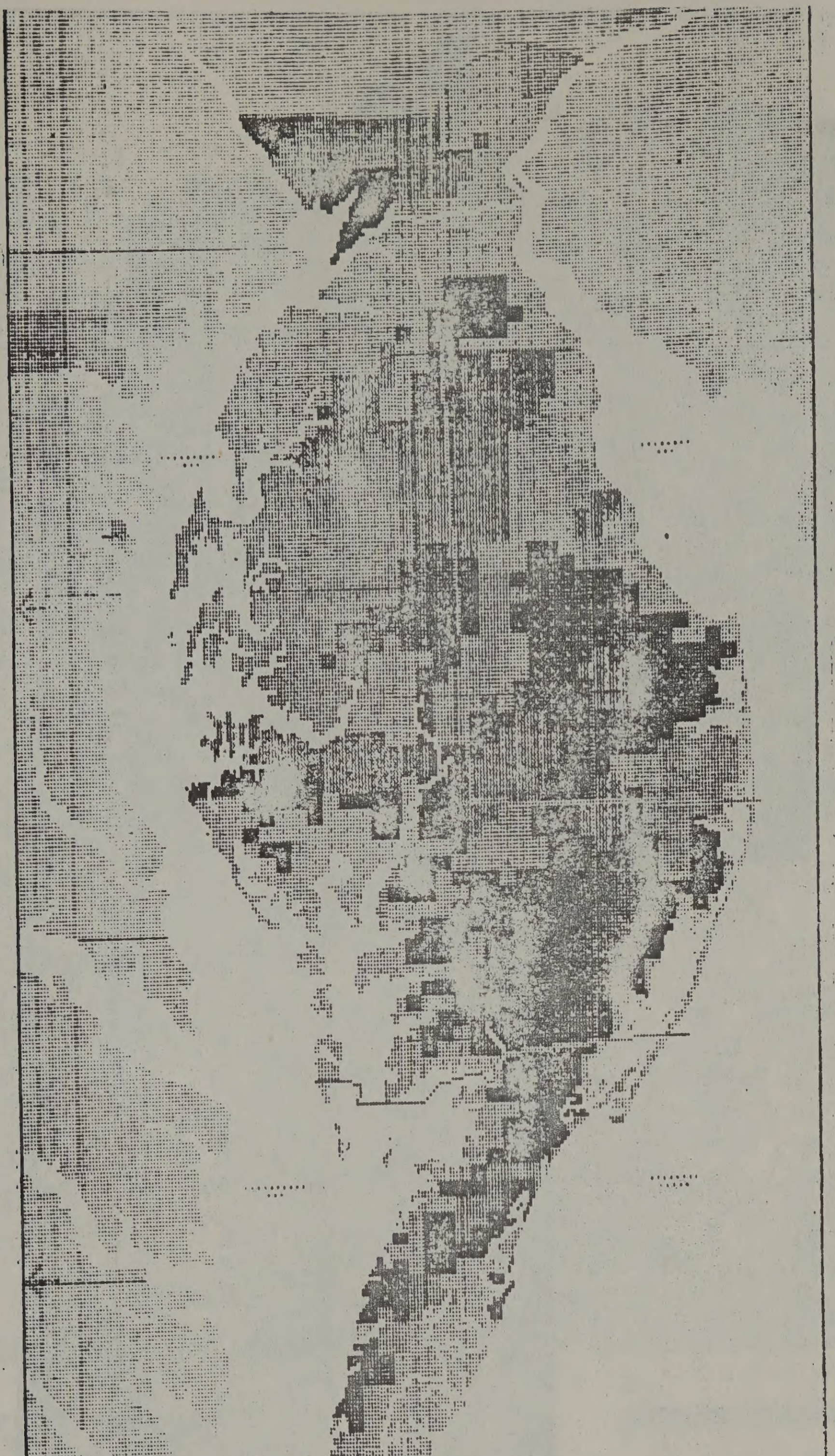


FIG. VI.5
FOREST DENSITY
(101.15.)

SYMAP with GRID Data System
1/2" x 1/2" Format;
Tone and Number Symbolism

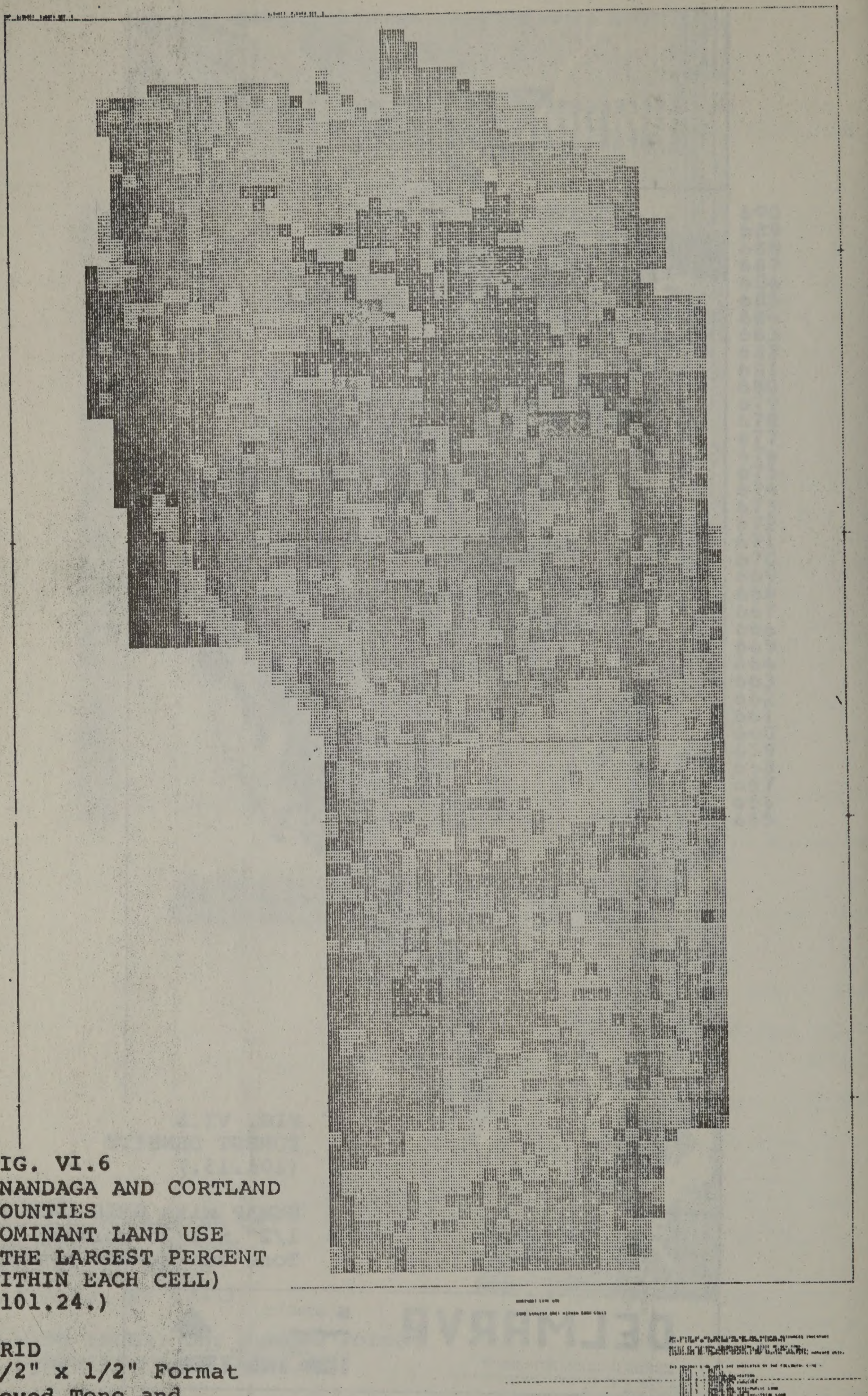
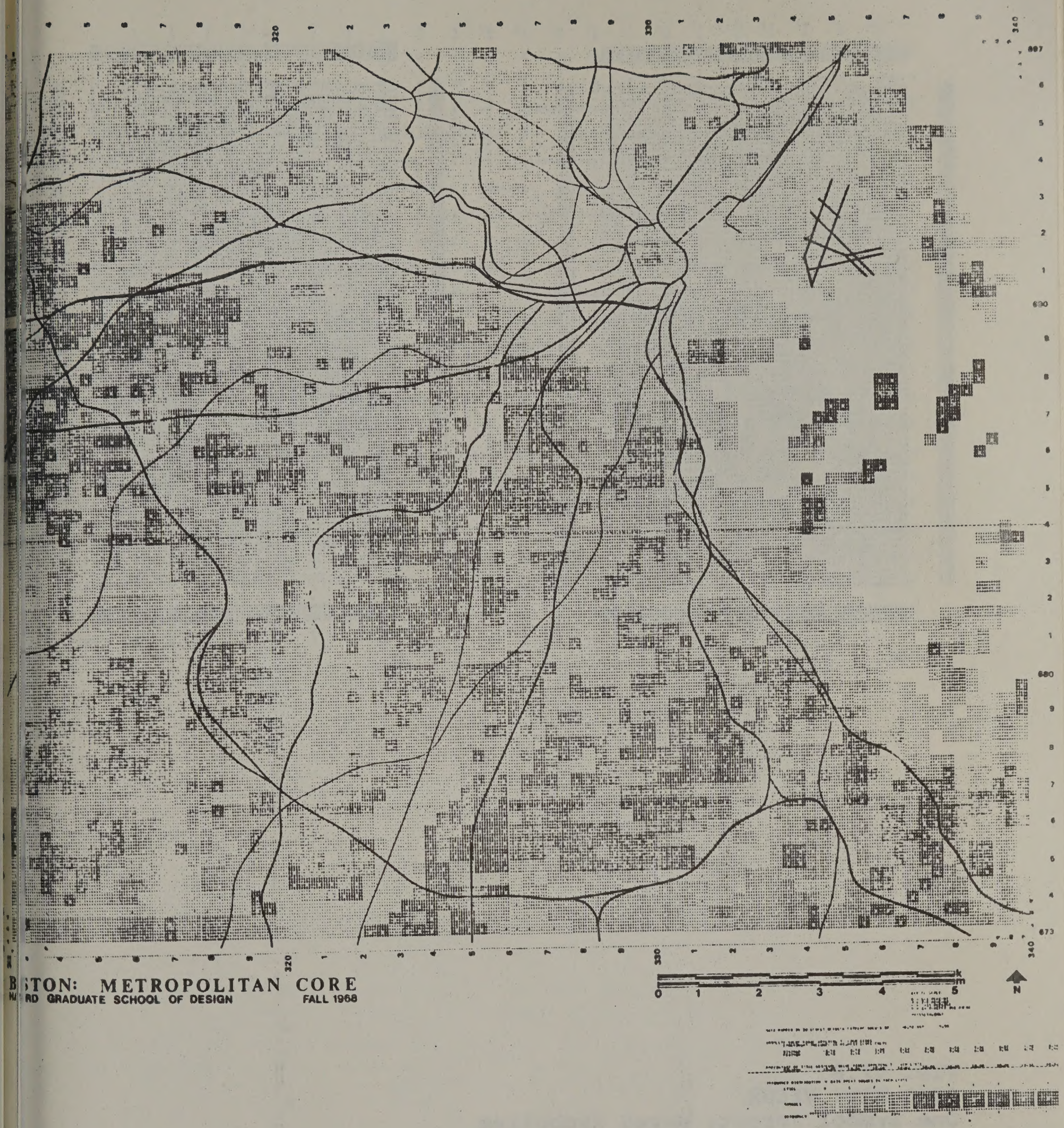


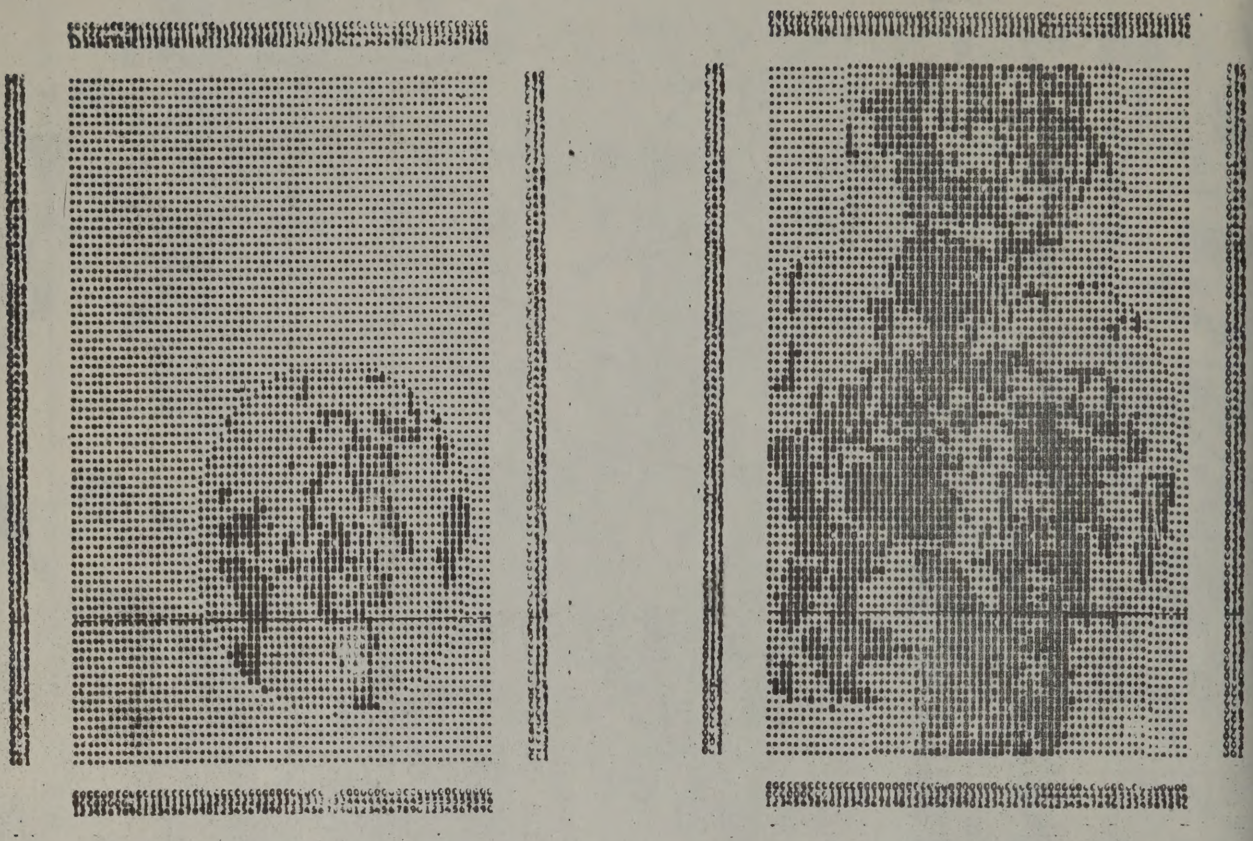
FIG. VI.6
ONANDAGA AND CORTLAND
COUNTIES
DOMINANT LAND USE
(THE LARGEST PERCENT
WITHIN EACH CELL)
(101.24.)

GRID
1/2" x 1/2" Format
Keyed Tone and
Number Symbolism



G. VI.7
POGRAPHIC SLOPE
ID; 1/2" x 1/2" Format
ne and Number Symbolism
th Overlay

rom Department of Landscape
chitecture, Harvard Graduate
hool of Design, Boston
tropolitan Core Study, 1968.]



a

b

FIG. VI.8
GRID WITH VIEWS
One Symbol Format; Keyed Symbolism

[From Studies by Sinton and Murray, (1969).]
   a) View area from southern end
      point of lake
   b) View area from lake perimeter

FIG. VI.13 provides an oblique view of the topography of this site.

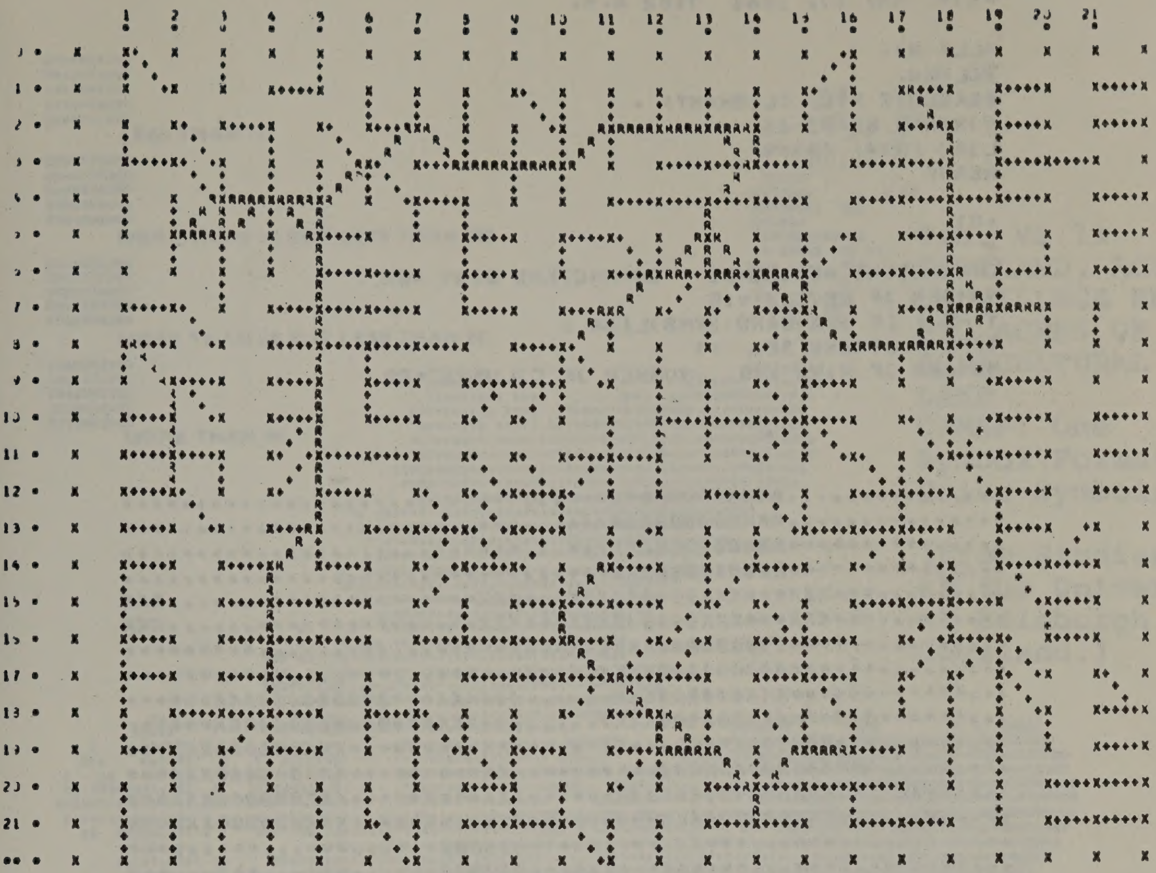
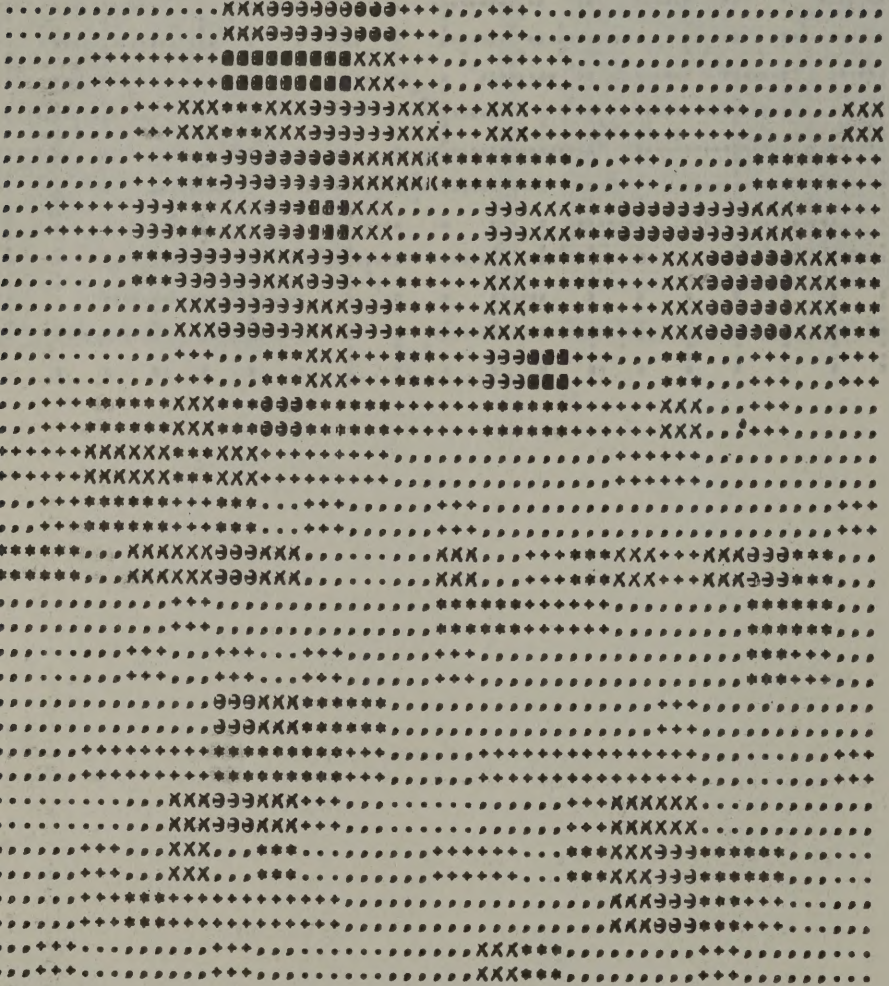


FIG. VI.9
DRAINAGE PATTERNS OF THE
CHARLES RIVER BASIN
GRID WITH FLOWS
One Symbol Format; Keyed Symbolism
(101.10.)

```
@TIME USED
CPU: 00:00:27
C)NNECT: 00:30

FR)M  MAY 17, 1968  7:02 A.M.

ALL? N).
@CLEAR.
@EXECUTE FTC  (LIBRARY) .
F)RTRAN 02-03-68
L)AD FR)M: /BSYM/
READY

+G)

CHARACTERS ACR)SS=03   CHARACTERS D)WN =02
NUMBER )F LEVELS =10
TYPE 1 IF STANDARD SYMB)LISM ,
TYPE 0 )THERWISE   :1
NUMBER )F R)WS =20   NUMBER )F C)LUMNS =20
```



```
ST)P
+
+
@TIME USED
CPU: 00:00:43
C)NNECT: 00:44

FR)M  MAY 17, 1968  7:02 A.M.

ALL? N).
@
```

FIG. VI.10
FRAMINGHAM, MASSACHUSSETTS
RESIDENTIAL DENSITY
TELEGRID; 1/2" x 1/2" Form t
Tone Symbolism

[From Studies by David Sinon
and Frank Rens, (1968).]

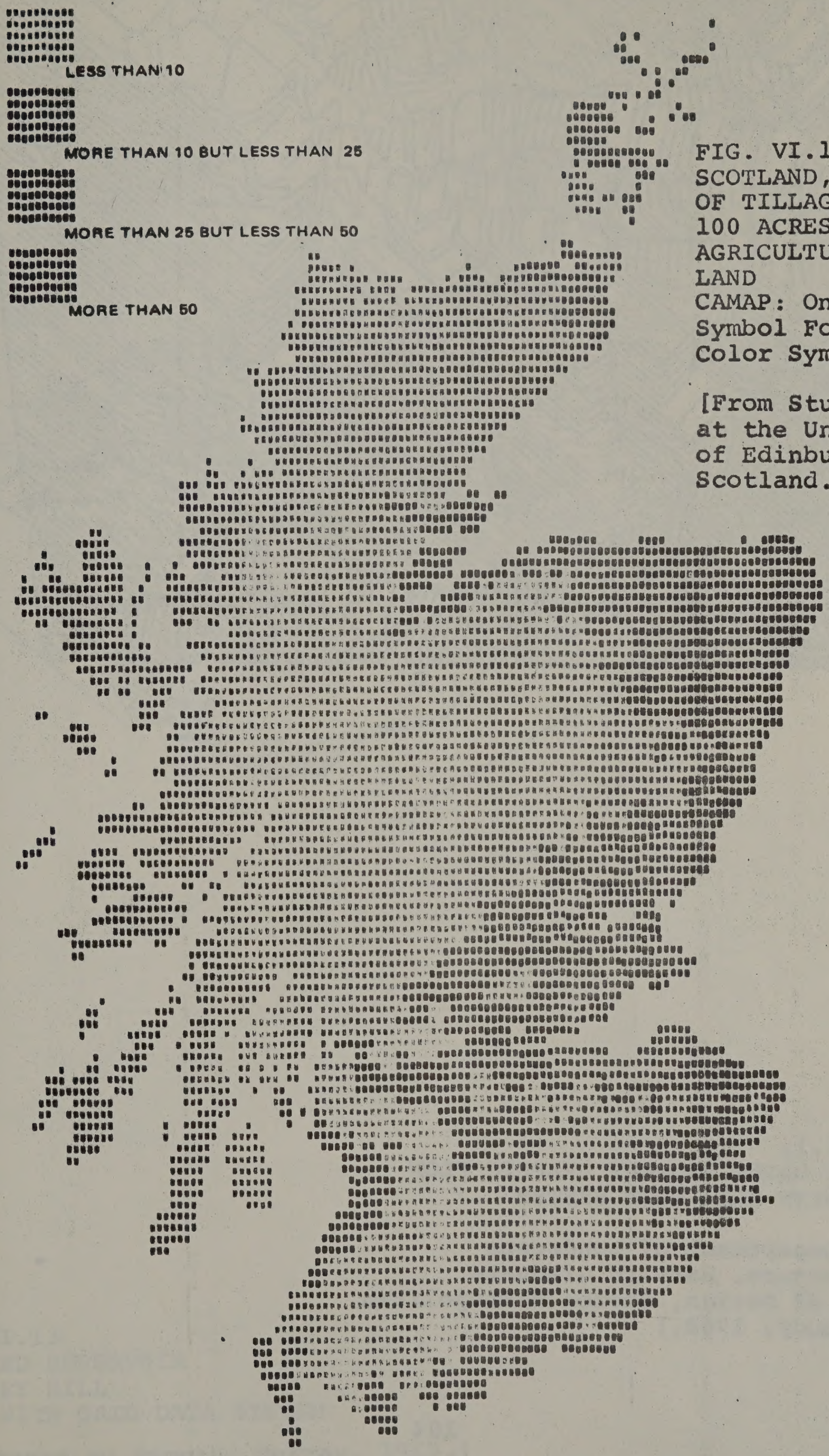


FIG. VI.11
SCOTLAND, ACRES
OF TILLAGE PER
100 ACRES OF
AGRICULTURAL
LAND
CAMAP: One
Symbol Format,
Color Symbolism

[From Studies
at the University
of Edinburgh,
Scotland.]

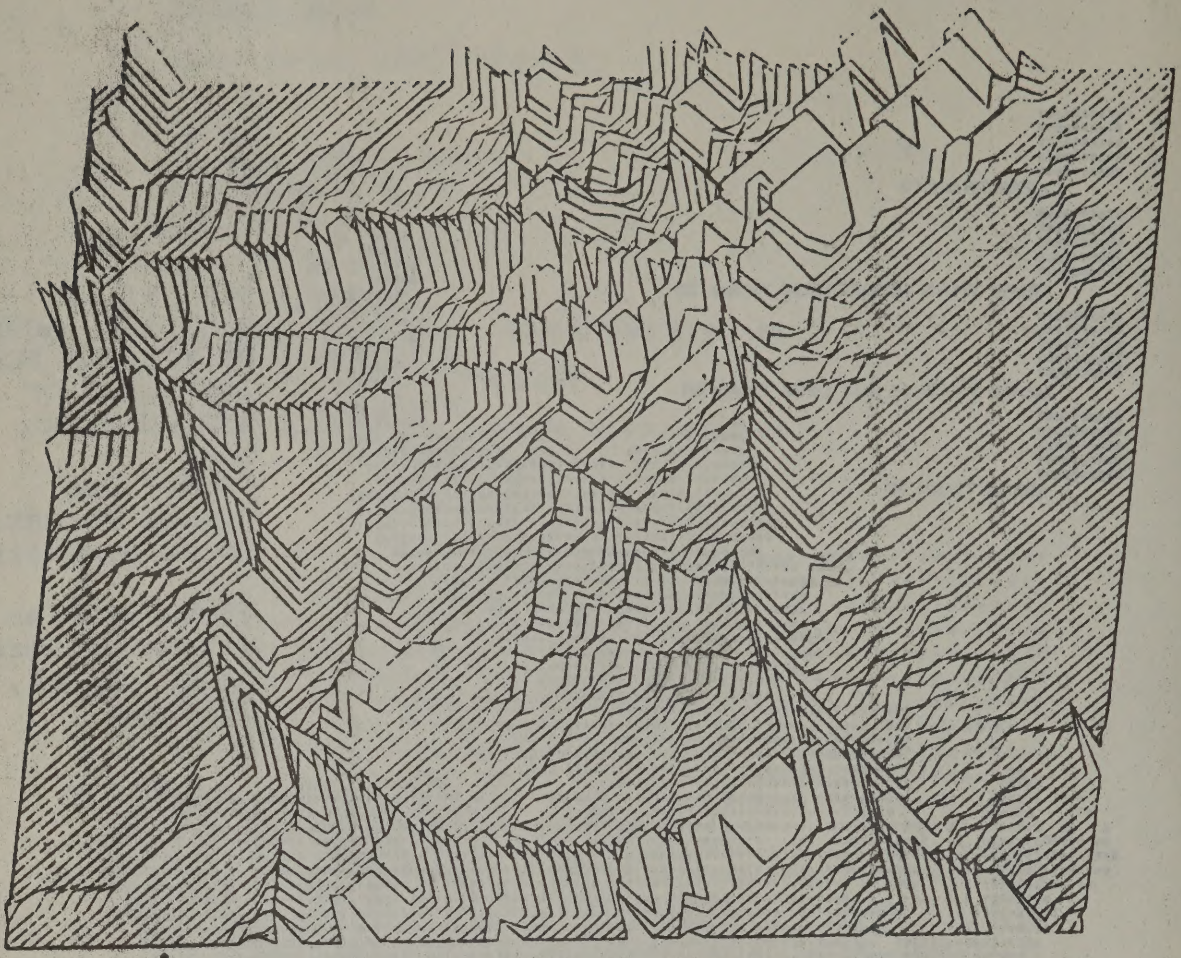


FIG. VI.12
AVERAGE DAILY TWO-WAY TRAFFIC FLOW
SYMVU WITH GRID DATA SYSTEM

[From Department of Landscape Architecture, Harvard Graduate School of Design, Boston Metropolitan Core Study, 1968.]

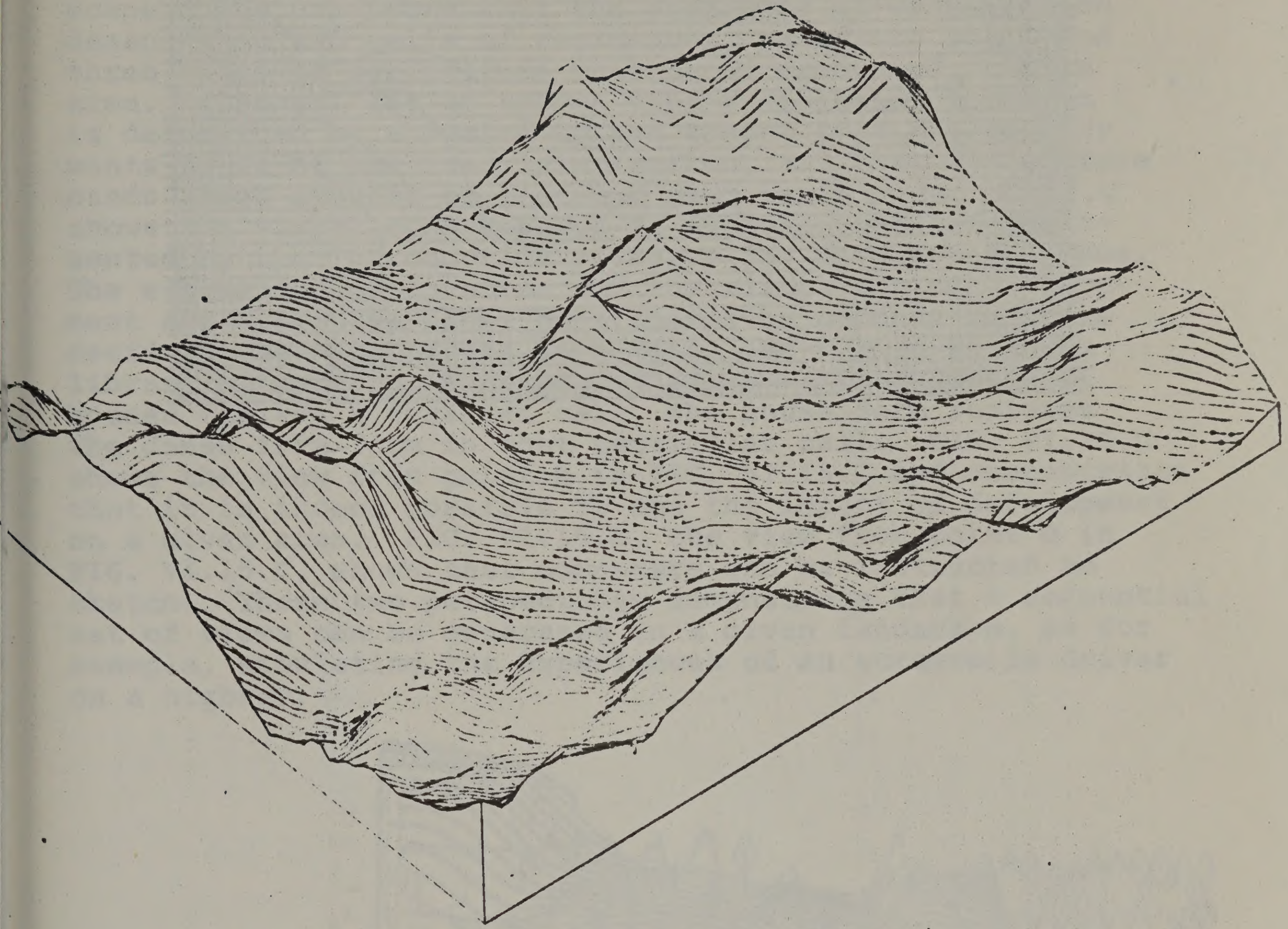
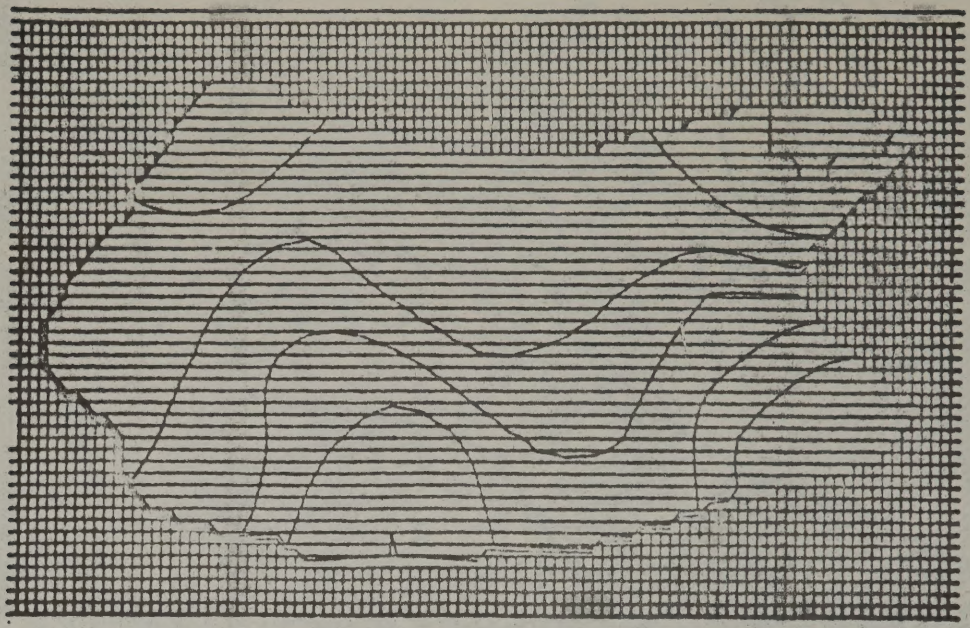


FIG. VI.13
PROPOSED RESERVOIR
AT HONEY HILL
SYMVU WITH GRID DATA SYSTEM

[From tests by Timothy Murray, 1969.]



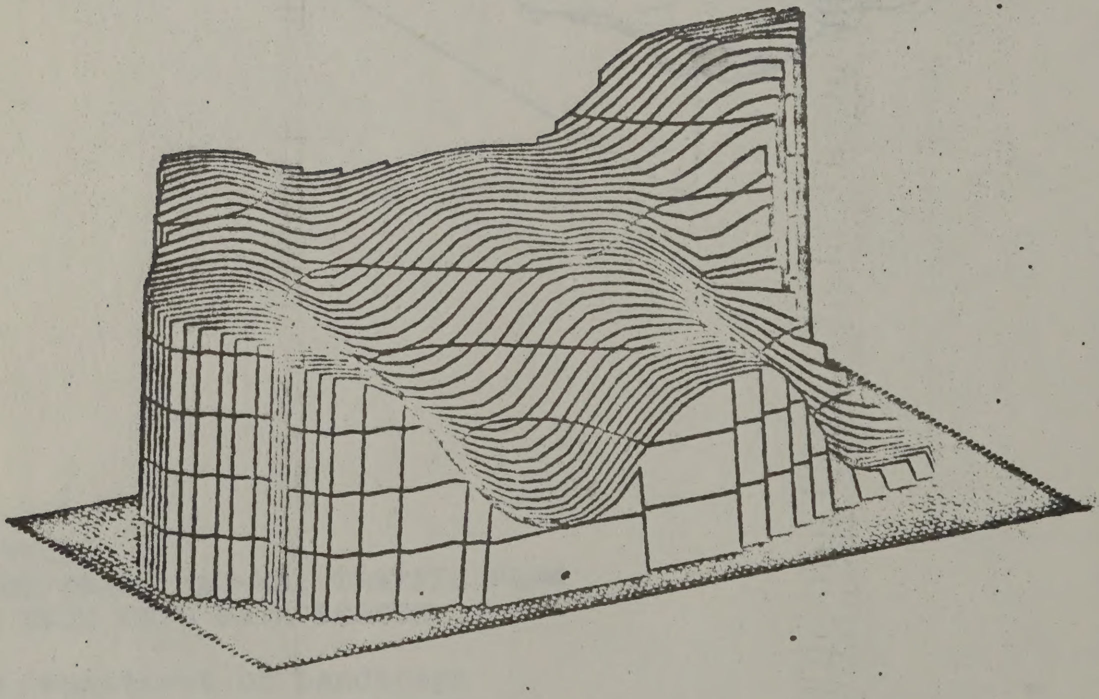
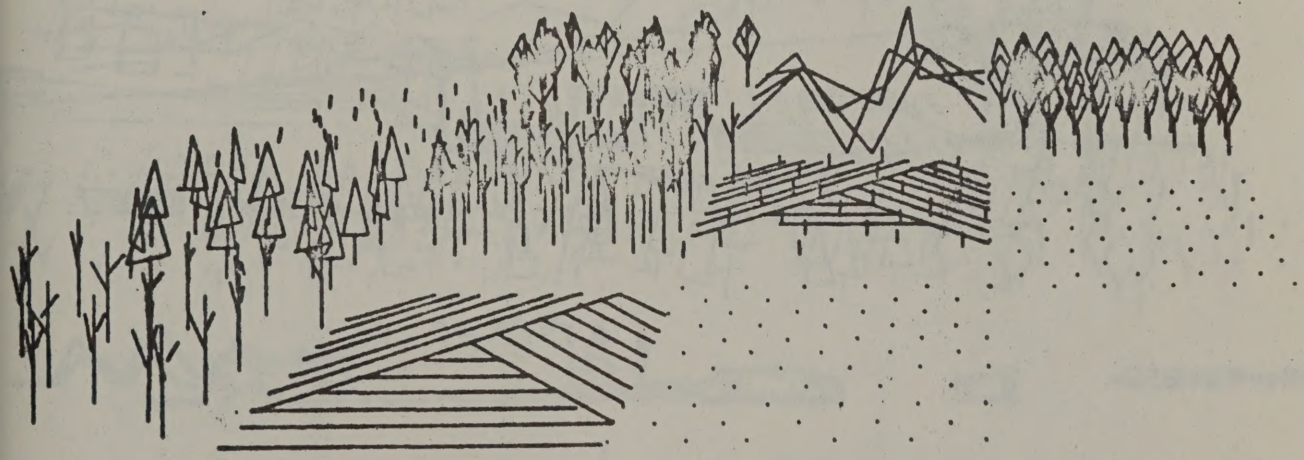


FIG. VI.14
OBLIX WITH GRID DATA SYSTEMS

[From tests by Adrian Thomas, 1970.]

FIG. VI.15.A is a bird's-eye perspective of a twelve cell grid, showing various types of herbaceous groundcovers. It demonstrates that a few basic types can be combined to make a wide variety of types and densities.

FIGS. VI.15.B through VI.15.E are the second experiments. FIG. VI.15.B represents an undeveloped twenty cell landscape. Let us assume that the pressures of urbanization demand that two cells of residences, a factory cell, and three cells of agriculture must be accommodated in this area. Further, let us assume that residential location is determined by a desire to see trees, that the factory wants to be at the road intersection, and that agriculture needs large amounts of flat and open land. FIG. VI.15.C shows the visual consequences of such allocations represented by the introduction of forms for development types. The evaluation of location and the allocation of development are accomplished by hand and/or by computer. These decided, the appropriate form types are called from the library of symbols, located and drawn. For example, if houses replace a forested cell, the house form replaces the dense tree form in that particular cell. FIG. VI.15.D shows the view from point A in FIG. VI.15.C and demonstrates that it is indeed possible to see the impact of development on a given area. FIG. VI.15.E, the view from point B in FIG. VI.15.C, shows that computers can be instructed to sketch. These two perspectives demonstrate that a sequential set of views can be generated in a given landscape, as for example, simulating the experiences of an automobile driver on a highway.



G. VI.15A
OTROL WITH GRID DATA SYSTEM
rom Studies by Carl Steinitz and Eric
icholz, 1968.]

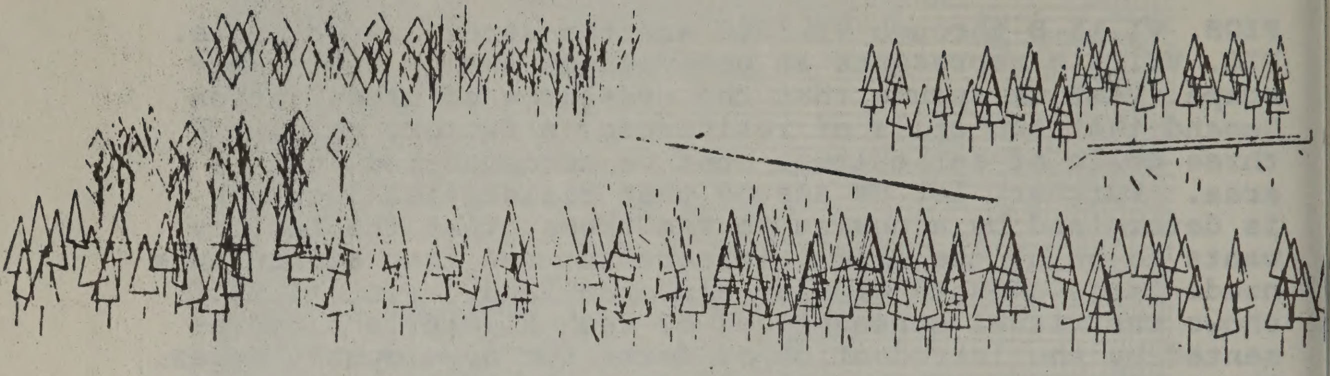


FIG. VI.15B

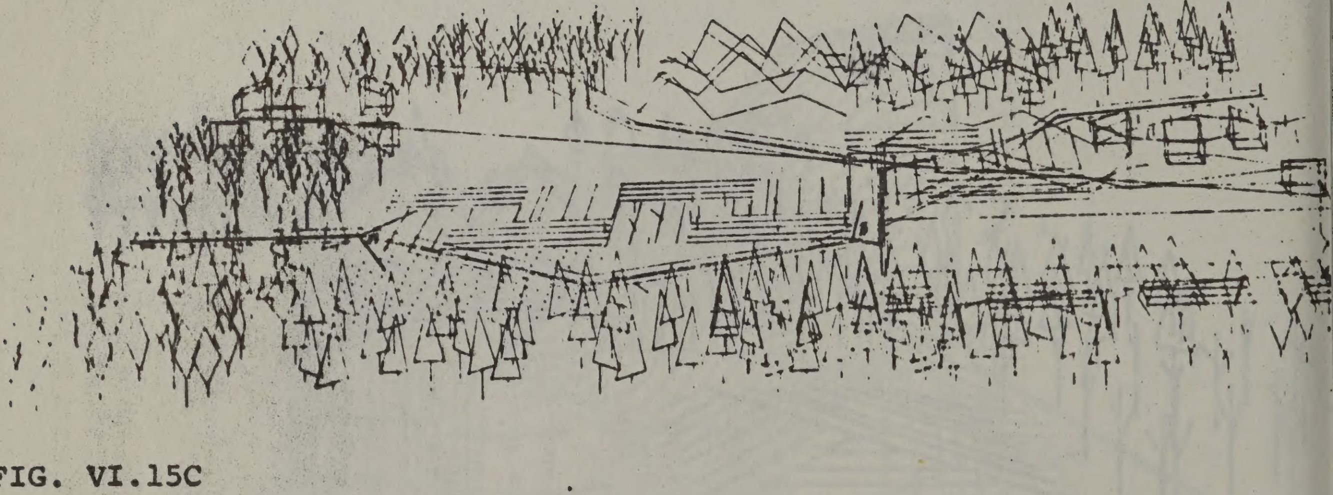


FIG. VI.15C

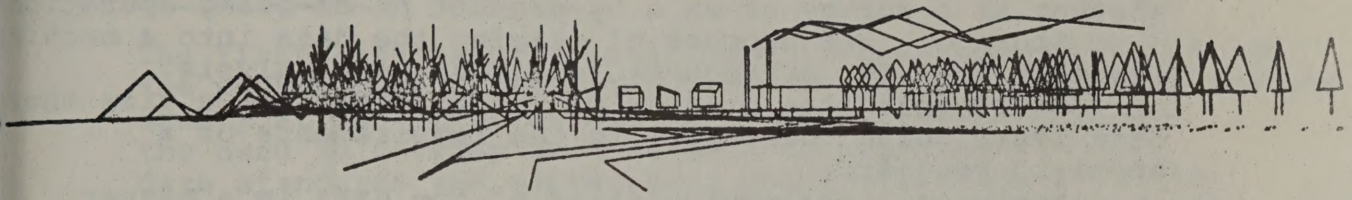


FIG. VI.15D

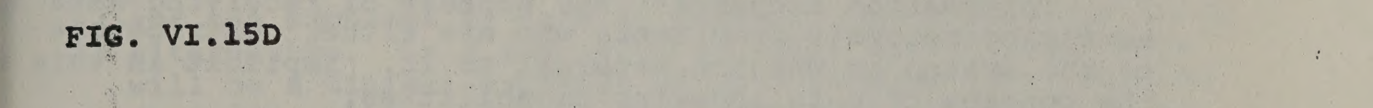


FIG. VI.15E

CHAPTER VII

CONSIDERATIONS FOR MANAGEMENT

A. Management Issues in Organization

1. Centralization vs. Decentralization

Preceding sections have emphasized that the definition of functions is a prerequisite to system design. For example, the functions could include:

Data Collection and Coding: the process of identifying, collecting and recording data including the presence, location, quantity or quality of given data measurements whether as a survey or as a by-product of on-going operations

Storage: the process of placing the data into a machine readable form for subsequent retrieval and analysis.

Retrieval: the process of withdrawing from a file those data items which correspond to the requirements of a specific request.

Analysis: the manipulation of the data in a manner designed to extract information relevant to the needs of a specific user.

Information Exchange: the process of receiving data and servicing requests from users who are either contributors to the system or who are external to it. Implicit in this is the concept of data indexing capabilities.

As there are numerous functions which might be performed by a resource analysis system, there are also numerous administrative arrangements which could relate participating agencies and groups. The functional configuration of an operational system organization may vary from complete decentralization to complete centralization. This can be illustrated in the following manner:

	Alternative Administrative Arrangemen					
	#1	#2	#3	#4	#5	#6
Data Collection and recording	L	L	L	L	LL	C C
Geocoding and categorization	L	L	L	L	C	C
Storage and Retrieval	L	L	L	C	C	C
Analysis	L	L	C	C	C	C
Information Exchange	L	C	C	C	C	C

L: Local Agencies

C: Central Agencies

The logical construct of this diagram and the alternatives which result from it are derived from a study by T. R. W. (18, pp. 3-14).

Each of the alternative administrative arrangements represents a slightly different approach and emphasis of function from the others. Alternative numbers 1 and 6 represent total centralization and decentralization respectively, and as such are polar extremes. In evaluating each extreme as well as the intermediate alternatives, a number of criteria must be considered including cost, capability, and acceptability.

Alternative #1

The first alternative, total decentralization, provides for the performance of all of the functions by every participating agency at its local level. A significant problem is the need to develop and maintain an acceptable set of data standards and conventions which will facilitate the exchange of data between essentially autonomous entities. Such an alternative would clearly have the greatest political acceptability although its level of performance and the exchange of data is probably lower than any other alternative. As a result it is quite likely that there will be a minimal exchange of data between participating agencies, with attendant duplication of data as well as under-utilization of those data which are available. Though local agencies are often unable to justify an adequate level of expenditure, cost considerations are likely to be relatively high due to the duplication of human and machine resources within local agencies.

Alternative #2

The second alternative requires the existence of a central clearinghouse facility which will provide a capability for exchanging information anddwhich should significantly improve the exchange of data. In addition, the provision and enforcement of data standards is also facilitated since they can be administered by a central agency. Some net cost savings are likely because the search for data by users is facilitated and the effort required of the responding agency is reduced. A single responsibility must be established for the purpose of evaluating the honoring of requests for exchanges of data.

Alternative #3

This option adds the function of analysis to the list of responsibilities for a central facility. At this point the central facility would likely develop greater machi and human resources than those of any participating local agency. By the same token, though, the capability for analysis which would be available to any participating agency via the central agency will exceed that available under Alternatives 1 or 2. It is also likely that the total system cost would increase less than the increase in capability which derives from a concentration of analytical resources. Indeed, the costs might decline. Such a combinat is less likely to be politically acceptable because it potentially overshadows accomplishment at the local level.

Alternative #4

Under this option the central facility effectively assumes responsibility for all computer operations related to the data bank. This alternative would be most desirable from the standpoint of adapting and enforcing a uniform set of data processing procedures and this should be reflected in cost savings and/or increased capability. As a potential political liability, the central facility now has access to every agency's data file and as a result the agencies hav lost a degree of autonomy over their data, but not their analyses.

Alternative #5

Under this arrangement, the central agency is able to establ standards for geocoding and categorization of data, two processes which are extremely important for subsequent sharing and exchanging of data sets. However, the local agency has retained its responsibility for collecting raw data and providing it to the central agency, tasks which are particularly appropriate when the by-products of an operating agency are to become inputs to a central data file. The political acceptability is still reasonable because the source of data is under local control. In addition, the local and central agencies are each assuming responsibilitie for functions which are appropriate to their administrative level.

Alternative #6

This option implies a total dependency of local agencies upon a single central agency with respect to all aspects of the data system. The attractiveness of this alternative is increased if the data are collected by means of original surveys, rather than if they are merely the by-products of data normally collected by the operating agencies. However, benefits such as complete standardization of all procedures would more than offset by the disadvantages of reduced involvement and acceptance by local agencies. In addition, there is a potential duplication of effort since data collected by the central agency often could have been obtaine as a by-product of the local agency's operation. In general, this alternative seems undesirable because of the total loss of local autonomy.

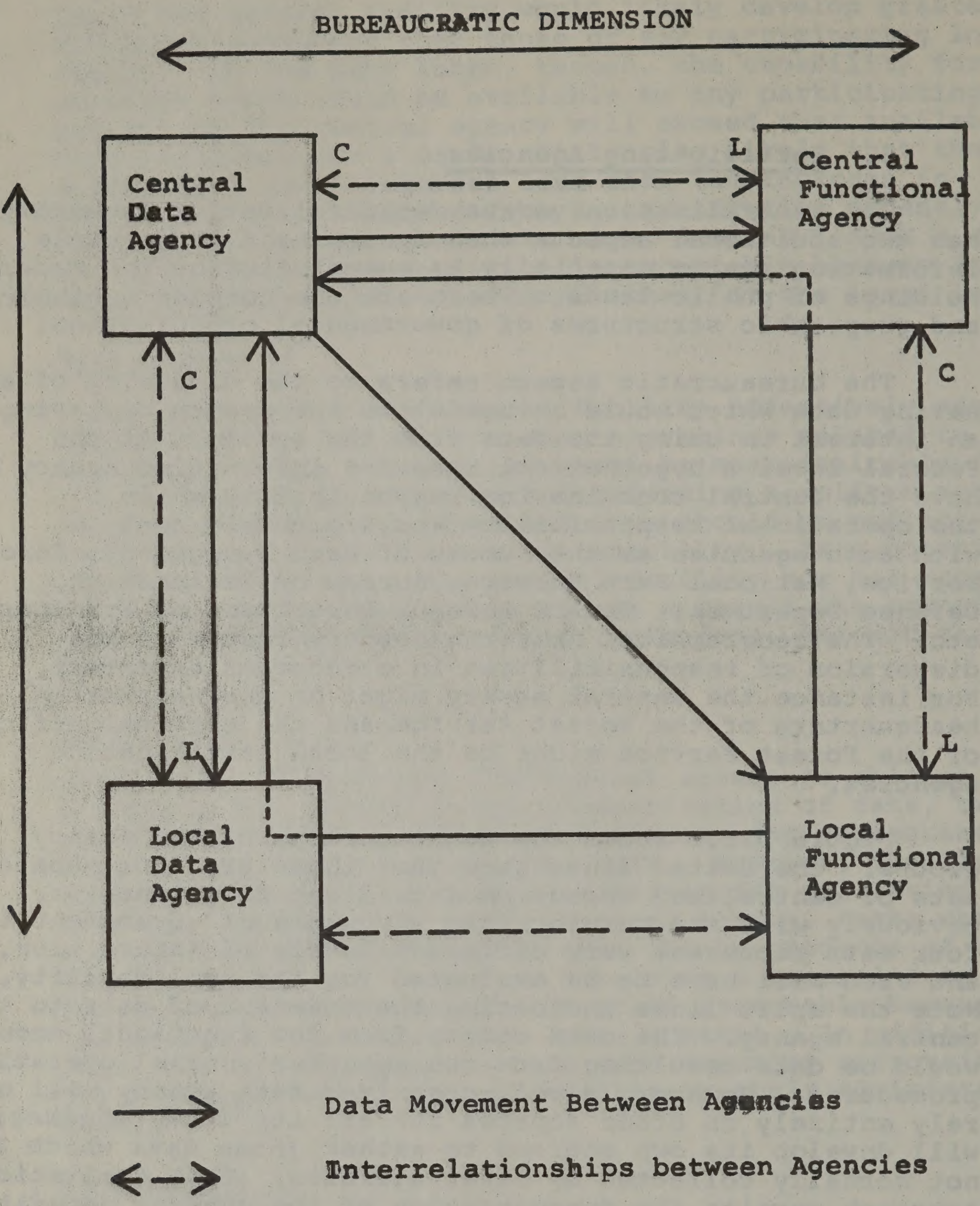
2. Participating Agencies

The centralization versus decentralization dichotomy has two additional aspects when designing a large scale information system especially as exemplified by the Federal holdings of public lands. These are the complex bureaucratic and geographic structures of governmental organization.

The bureaucratic aspect refers to the diversity of agencies having data which would be useful to the system or having an interest in using the data from the system. At the Federal level a hypothetical resource information agency could have the central coordinating responsibility while the operational responsibility would probably rest with such agencies as the Bureau of Land Management, Forest Service, National Park Service, Bureau of Reclamation, Defense Department, Census Bureau, Department of Transportation, etc. The geographical hierarchy aspect refers to the dispersion of responsibilities in a geographic context. For instance the central agency might be the Washington headquarters of the Forest Service and the regional offices of the Forest Service might be the local participating agencies.

Figure VII.1 shows the relationships of the agency groups. The dotted lines show that there are four separate sets of centralized versus decentralized relationships. Obviously with the bureaucratic structure of government these four sets represent very different levels of interaction, and each will have to be evaluated for its applicability. Note the split lines indicating the movement of data to the central agency. The data coming from the functional agencies would be data resulting from the agencies' normal operating procedures. However, a well-organized data agency will not rely entirely on other sources for all its data. Rather, it will develop its own sources to gather those data which are not normally collected by other agencies. This dualistic approach permits the demonstration of the general benefits of the data system to be made in pilot studies before any large scale commitments are made.

General terms have been deliberately used in Figure VII.1, since the schema implied in the diagram could be applied at any level of organization with differing sets of alternative interactive relationships. For instance, a State Planning Office might be the Central Data Agency for a state-wide system, while it might simultaneously be a local data agency in a Federal system. The scale of the system may well affect the alternative organization that is chosen, since in a nationwide system the amount of information that is involved would probably preclude a single central


BUREAUCRATIC DIMENSION
Central Data Agency
Central Functional Agency
Local Data Agency
Local Functional Agency
C
L
C
L
C
L
Data Movement Between Agencies
Interrelationships between Agencies

THE DIMENSION OF MANAGEMENT
FIG. VII.1

computer operation. This would mean that the computing sections would rest with a regional or local data agency. On the other hand, for a small state or a city it would be feasible to centralize computing. Similarly, at the Federal level each agency would retain its own computing activities, but at the level of a small region agencies could profitably share a computing facility. The section on systems resources suggests some of the reasons for centralizing the computing resources, but the exact location of centralization in a complex system should be carefully considered in terms of both the geographic hierarchy and the bureaucratic system.

In summary, and as a general rule, data would be in the public domain and therefore the system should be made available for use by all interested groups. Specific analyses however may well be considered proprietary. Precedents exist for the availability of data, as well as for the sharing of systems costs among governmental agencies and, by means of use-fees, among private interests.

B. Management Issues in Systems Design

1. Previous Problems

During the last ten years the establishment of data banks by planning and other governmental organizations has been a very popular activity. Unfortunately, the success of those operations has in no way equalled the enthusiasm with which they were undertaken. In most cases, planning agencies have been attracted to the computer success stories which abound in the magazines and newspapers of the every day world. Not knowing, and in some cases perhaps not wanting to know, of the requirements and costs of successful data processing applications, and more important, not knowing of the very high failure rate in such undertakings, the governmental data-banker-to-be has often been attracted to the punched card like a moth to the flame.

Typically, information systems have been concerned with recording many characteristics, such as land use, zoning, building type or assessment, for each parcel of land. The assumption behind this energetic undertaking was that once the data had been harvested it would be possible to glean from the data numerous items of immediate and long range concern to the local planning operation. However, once the data bank had been established, some of the following facts often came to light.

1) The "wrong" data had been recorded, in that the data requested by potential users was not recorded or was recorded in a manner which reduced its usefulness.

2) The data as recorded contained too many errors.

3) The data was too difficult or costly to retrieve because the requirements to do so were not considered when the data were originally collected.

4) The cost of operating the system far exceeded original estimates and the benefits derived were far less than had been expected.

5) There was some uncertainty as to just what was recorded and how it was recorded, and,

6) There was even greater uncertainty as to why it was recorded in the first place.

As a result, many data banks became data dumps, and when a given set of data was needed, it was often more economical to regather the data than to attempt to retrieve it from the data bank.

2. System Goals

The data bank problems of the past would often have been reduced or avoided if those responsible for the design and operation of the data banks had observed that automated data is in itself a useless goal; electronic data processing applications must be based upon the automation of specific, understood analysis tasks and not merely upon the data associated with these activities. The use of the system must govern the design. Computers and computer programs are capable of handling great quantities of data -- but only within the extremely precise limits determined by the characteristics of the data, the storage method and the capabilities of the hardware and software used. As a result, the only way that one can have any confidence at all in being able to use the datawhich he proposes to place into a data bank is by first identifying the range of specific requests which he will later make of the data bank and then determining the specific stored data which will be required in the data bank to satisfy his reques
Then he must specify precisely what operations he wants the computer to perform on these data and how the computer will do this. At the same time, the goal should not be to design a system to serve a few specific functions so well that it can never be used for any other purpose in the future. Sufficient flexibility must be designed into the system to allow it to perform a variety of tasks which may be identified later as well as those specified at the very beginning. The work done must constantly reflect specific

ultimate goals plus the basic immediate requirements. The work must also recognize current and probable future changes in computer technology and provide sufficient flexibility to accomodate and take advantage of such developments as they occur.

3. Some Important Questions

One of the first tasks normally performed in the development of a computer application must therefore be an analysis of the system which is to be automated. Such an analysis would include an initial detailed statement of the present as well as the future systems operating characteristics. In addition, such a study would describe the procedures, data, equipment, programs, and personnel which are required in order to place the entire automated system into full operation on some given future date.

Only after having labored over what one wishes to do with the data and how one proposes to do it, can answers to some very important questions be developed. Is it possible in the first place? Do computer equipment and programs exist to do the job? Is it feasible; that is, what will it cost and what is its value? At this point, a realistic estimate of the value of the task or benefits to be realized by the results should be made and compared to the cost of doing the job by computer. The cost of other methods for achieving the same goal should be known and should include alternatives, if any are applicable, which do not use computer techniques. When the task is defined, the necessary data identified, and computer methods and means are available to do the job at a cost not exceeding the value of the job, further questions about the data banks arise. The costs of alternative methods of coding and storing data should be compared and the effect of this cost upon the cost of the job considered. Also, data should not be placed into a bank until it is certain that the goals cannot be accomplished by using data in an already existing data bank.

As a general rule, these management issues are raised about a system designed to do a minimum of known and needed tasks. If this system design is judged feasible, it is because that minimum was satisfied. Once implemented, the system is available for previously unforeseen uses, many of which can be guaranteed to exist in almost all computer-based, resource analysis systems. Beyond that minimum use, everything represents clear analytic advantage as well as efficiency.

C. Required Resources

The various resources required to implement a system of the type referred to in this report can be categorized as data, computer equipment, computer programs, and personnel Each of these can in turn be roughly measured in terms of dollars.

1. Data

Experience with systems of the types being discussed has shown that of these four requirements or resources, much of the data is usually readily available, and in some cases overwhelms the user with its sheer volume. Concern for how the data are collected, recorded, coded, stored, and analyzed is likely to be much more relevant than merely accessibility to raw data. Data, specially those referring to natural resources, are often quite old and were collected before modern methods or theories were in widespread practise It is therefore sometimes easier and less costly to collect new data than it is to reinterpret existing data. The comparative costs and quality of existing and newly collected resource data should always be carefully studied.

2. Computer Hardware

Computer equipment was originally thought to be the primary concern of those wishing to automate a process. Over the last years, however, availability of equipment has become increasingly less important. This has been due not only to ever growing numbers of computers but also to the development of computer hardware which has been designed to service many users in a shared-time environment and also to allow for remote job entry and batching of programs. In effect, any organization needing access to computer hardware is now able to choose from a variety of vendors from whom it may buy or rent the machines or the time on the machines, which it needs. The ability to provide remote terminal access to data is almost a prerequisite to a highly centralized system of data management. Without such a system the delays in access to the data will reduce the utility of the data system to the low level user.

3. Computer Software

The purchase or lease of a computer costs a great deal of money and those who have invested in such equipment have often felt that this would be by far their single largest expenditure in the development of an automated system. However, another substantial cost is involved in preparing the programs to be run on the machines. An extremely important factor in the cost of program development is the available personnel. Although many people have been attracted to the field of computer programming, some are more equal than others. The result is that one very good programmer or systems analyst can perform a given task in a fraction of the time required by several less capable individuals, if indeed they can produce a comparable product at all.

4. Computer Personnel

The phenomenal growth rate of computer applications has not been nor is likely to be matched by an equal number of people who have been trained and are highly proficient in the use of computers. As a result an ever growing number of firms have been formed which provide assistance in the development of computer systems for specialized applications. Such firms should not be used to operate and maintain an operational system since this capability should be developed within the agency responsible for the process to which the computer contributes. This is important in order to maintain the continuity of the operation and to minimize the dependence of the agency upon the presence of the consultant. However, such a firm could be invaluable in assisting in the initial design and implementation of a system as well as in providing periodic evaluations and recommendations concerning its operation. The magnitude and potential impact of a system of the kind discussed in this report requires that the best possible personnel be employed to insure its greatest possible utility at its minimum possible cost. The scarcity of good personnel for the day-to-day operation of a system almost requires that the computing operations of a data system be more or less centralized in order to decrease the number of personnel required to operate the system.

D. Pilot Studies

The pilot study is one of the best means for evaluating the procedures needed as well as the costs involved. A complete pilot study provides an opportunity to evaluate the entire set of proposed procedures ranging from the collection of raw data to the production of the final analysis.

Of even greater importance than the development and testing of procedures is the opportunity afforded by a pilot study to obtain experience and additional information about the actual costs involved in performing the entire operation. Unforeseen costs will be identified and many new obstacles and requirements will appear as a result of the pilot study. The pilot study itself is not likely to uncover every possible contingency of the fully operational system but if properly conducted it will certainly identify the majority of them. It will also provide an opportunity to recognize possible errors and deficiencies in the system and to provide an opportunity to correct them at the pilot study level. If these were not identified until the entire system was near completion, the cost of correcting them would be prohibitive and the entire system seriously hobbled or made unworkable. Experience has shown that a pilot study, like a shakedown cruise for a new ship, is an invaluable intermediate stage between system design and full implementation.

CHAPTER VIII

CONCLUSIONS

In terms of the techniques which can be applied to resource analysis, the advantages and disciplines of computer use seem clearly demonstrated. The lack of computer use has constrained resource analysis to relatively simple techniques using broad classes of data and relatively few variables. The use of computers in resource analysis can be expected to continually evolve from fairly uncomplicated to relatively sophisticated applications.

One of the major potential impacts on resource analysis studies of the future will be the greater availability of more, and more accurate, data provided by the new technologies of satellite-sensing and aerial photography. These data will come to the user directly in computer compatible form and then the challenge to the resource analyst will be to devise the means of understanding, analyzing, and manipulating those data. Not only will more data be available but various analysis programs themselves will probably become packaged. The various indexes and evaluation scoring systems which are so common today can then be internally studies, so that the effects of what now must be considered essentially subjective bases of evaluation can become more objective. The time and costs required for making these analyses will drop radically through computer use, and there is every reason to believe that the quality of resource analysis will improve. The evolution of computer graphics will be accompanied by changes in the equipment and programs which will continue to grow in quantity, quality, and compatibility, with substantial concurrent reductions in unit cost.

It will obviously become increasible important to develop an understanding of the numerous potential uses of computers for resource analysis as well as an understanding of their limitations. The dominant developing trends in environmental resource analysis are toward the kinds of systems which we have described -- general data inventory and data handling systems, coupled with specialized and interrelated analysis models, all being computer compatible for analysis and graphic output.

These systems are feasible now. Prototypical systems have been designed, tested, and made operational at several scales and levels of government. Their combination of low cost in time, personnel, and dollars relative to a virtually unlimited analytic potential, make such an approach one which should be considered in almost any large and complex planning area. Their potential applicability in determining the future of America's 746 million acres of public lands is clearly demonstrated.

BIBLIOGRAPHY

1. Aerotriangulation: Transformation of Surveying and Mapping Coordinate Systems. ESSA Technical Report C&GS 34, U.S. Department of Commerce, August, 1967.

2. Amidon, Elliot L. A Computer-Oriented System for Assembling and Displaying Land Mangement Information. U.S. Forest Service Research Paper PSW-17, U.S. Department of Agriculture, 1964.

3. Amidon, Elliot L. MIADS 2...An Alphanumeric Map Information Assembly and Display System for a Large Computer. U.S. Forest Service Research Paper PSW-38, U.S. Department of Agriculture, 1966.

4. Amidon, Elliot L., and Elsner, Gary H. Delineating Landscape View Areas -- A Computer Approach. Forest Service Research Paper PSW-180, U.S. Department of Agriculture, 1968.

5. Anson, A. The Use of Color Aerial Photography in the Reconnaissance of Soils and Rocks. Materials Research and Standards, American Society for Testing and Materials, Philadelphia, Pa., February, 1968.

6. Arnis, Samuel. Map/Model System...Technical Concepts and Program Descriptions. Columbia Region Association of Governments, Portland, Oregon, February, 1968.

7. Aron, J.D. "Information Systems in Perspective." Computing Surveys, Vol. 1, No. 4, Dec., 1969, pp. 213-236.

8. Avery, T.E. Interpretation of Aerial Photographs. (Second Edition), Burgess Publishing Co., Minneapolis, Minn., 1968.

9. Barraclough, Robert E. "Geographic Aspects of Information Retrieval." Proceedings of the Second Annual Conference of the Urban Planning Information Systems Conference, University of Pittsburgh, Pittsburgh, Pa., Sept. 26, 1964.

10. Barraclough, Robert E., "Mapping and EDP." Presented at the Electronic Data Processing Session of the American Society of Planning Officials Annual Meeting, Toronto, Canada, April, 1965.

11. Barraclough, Robert E., and Rosenberg, Paul. "AULT System for Automatic Locational Identification." Based upon a paper presented at the ACSM-ASP National Convention, Washington, D.C., March, 1964.

12. Barringer, A.R. The Use of Audio and Radio Frequency Pulses for Terrain Sensing. Barringer Research Ltd., Rexdale, Ontario, Canada.

13. Belknap, Raymond, K., Furtado, John G., Forster, Richard R., and Blossom, H. Duane. Three Approaches to Environmental Resource Analysis. Department of Landscape Architecture, Harvard Graduate School of Design, The Conservation Foundation, Washington, D.C., 1967.

14. Bishop, Kendall H., and Gibson, Stephen C. Mapping by 1401 Computer Using MAP 01. Subdivision of Transportation Planning and Programming, New York State Department of Public Works, Albany, N.Y., March, 1966.

15. Boyce, David E., Goldfarb, Lawrence A., and Veitch, Edward W. "Prospectus for a Computer System for Urban Mapping." Institute for Environmental Studies, University of Pennsylvania, and Pennsylvania Research Associates, Philadelphia, Pa., no date.

16. Brounstein, Sidney H. "Some Concepts and Techniques for Constructing and Using a Geographically-Oriented Data Base." Socio-Economic Planning Sciences. Vol. 1, No. 3, July, 1968.

17. Burack, David, and Knox, James E. RESCAN...School of Natural Resources System for Cartographic Analysis. University of Michigan, Ann Arbor, Michigan, June 24, 1968 (draft).

18. California Regional Land Use System Project Second Interim Report. TRW Systems Group, Redondo Beach, Calif., August, 1967.

19. Calkins, Hugh W. Operations Manual for Street Address Conversion System. Research Report No. 2, Urban Data Center, University of Washington, 1965.

20. Calkins, Hugh W. "Ottawa Street Address Conversion System." Highway Research Record. No. 194, 1967, pp. 96-102.

21. Cameron, Scott H., Ewing, Duncan, and Liveright, Michael. DIALOG: A Conversational Programming System with a Graphical Orientation. IITRI Technical Note No. 109, Chicago, Ill., September, 1966.

22. *Census Use Study: Computer Mapping.* Report No. 2, U.S. Bureau of the Census, Washington, D.C., 1969.

23. Chess, Joel I. *Graphic Display System.* One of a series of SPAN reference manuals. TM-1563/025/00, Systems Development Corporation, March 31, 1966.

24. Chess, Joel I. *A Survey of Graphic Display Software for Off-Line Plotting.* TM-269/000/00.

25. Colwell, R.N. "Some Practical Applications of Multiban Spectral Reconnaissance." *American Scientist.* Vol. 49 No. 1, March, 1961, pp. 9-36.

26. Colwell, R.N. "Uses and Limitations of Multi-Spectral Remote Sensing." Proceedings of the 4th Symposium on Remote Sensing of the Environment, University of Michigan, Ann Arbor, Michigan, 1966.

27. *Computer Mapmaking: A User's Manual.* The Technical Record, Regional Planning Council, Baltimore, Maryland, no date.

28. Connelly, Daniel Stolz. *The Coding and Storage of Terrain Height Data: An Introduction to Numerical Cartography.* Master's Thesis, Cornell University, 1968.

29. *Context.* Published by the Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., February, 1968.

30. Cooke, Donald, F., and Maxfield, William H. "The Development of a Geographic Base File and Its Uses for Mapping." *Urban and Regional Information Systems for Social Programs.* Papers from the Fifth Annual Conference of the Urban and Regional Information Systems Association, Garden City, N.Y., September, 1967, pp. 207-218.

31. Cooke, Donald F. "Systems, Geocoding, and Mapping." Presented at the Annual Conference of the Urban and Regional Information Systems Association, Calyton, Mo., September, 1968.

32. *Coordinated Data System for Highway Planning.* Highway Planning Technical Report #7, U.S. Department of Transportation, Bureau of Public Roads, Washington, D.C., April, 1968.

33. "Design and the Computer." *Design Quarterly.* Walker Art Center, Minneapolis, Minn., 1967.

34. Dial, Robert B. "Street Address Conversion System." Planning 1965. Proceedings of the Joint Planning Conference of ASPO and the Planning Association of Canada, Toronto, Canada, April, 1965, pp. 319-330.

35. Dodd, George, G. "Elements of Data Management Systems." Computing Surveys. Vol. 1, No. 2, New York City, June, 1969, pp. 117-133.

36. Farnsworth, George L. "A Geographic Base File for Urban Statistical Analysis." Presented to the Committee on Small Area Statistics at the American Statistical Association Meeting, Pittsburgh, Pa., August, 1968.

37. Fischer, W.A. Spectral Reflectance Measurements as a Basis for Film-Filter Selection for Photographic Differentiation of Rock Units. Geologic Survey Research, 1960.

38. Fischer, W.A. "Color Aerial Photography in Geologic Investigations." Photogrammetric Engineering. Vol. 28, No. 1, 1962, p. 133.

39. Fisher, Howard T., et al. Reference Manual for Synagraphic Computer Mapping (SYMAP), Version V. Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., June, 1968.

40. Forbes, Jean. "A Map Analysis of Potentially Developable Land." Regional Studies. Vol. 3, pp. 179-195.

41. Gaits, G.M. "The General Concept of a Coordinate Referencing System for Land Use Planning," Stubbs, G.M. "Point Data and its Use," and Woodford, G.P. "The Use of Metric Grid for Town Study." Three papers presented during the session of "A Coordinate Referencing System for Planners" at the Third Annual General Meeting and Conference of the Regional Studies Association, Great Britain, October 14, 1967.

42. Goldstein, Harold, L. "Computer Mapping User's Study with an Emphasis on Planning." (Mimeo paper) Urban Studies Center, Battelle Memorial Institute, Columbus, Ohio, June, 1969.

43. Goldstein, Harold, L., Wertz, James, and Sweet, D., Computer Mapping: A Tool for Urban Planners, Urban Studies Center, Battelle Memorial Institute, Cleveland, Ohio, March, 1969.

44. Gould Ernest M. Jr., and O'Regan, William G. Simulation, A Step Towards Better Forest Planning. Harvard Forest Papers No. 13, Petersham, Mass., 1965.

45. Grid Coordinate Coding Program Technical Report. Detroit Regional Transportation and Land Use Study, May, 1967.

46. Hester, James Jr. Systems Models of Urban Growth and Development. Urban Systems Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., November, 1969

47. Howlett, Bruce, and Schneider, Harold. "The Use of Computer Graphics in the Hudson River Valley." Paper presented at the Second Annual Symposium of the Association for Computer Machinery, November, 1968.

48. Information. A Scientific American Publication, London, 1966.

49. Jacobsen, J.D. "Geometric Relationships for Retrieval of Geographic Information." IBM Systems Journal. Vol. 7, Nos. 3 & 4, 1968, pp. 331-341.

50. Keith, Robert E. Map Model-Parcel File Comparisons. Bureau of Governmental Research and Service, University of Oregon, Eugene, Oregon, April, 1968.

51. Kilbridge, M., O'Block, R., and Teplitz, P. "A Conceptua Framework for Urban Planning Models." Management Science Vol. 15, No. 6, no date.

52. Knode, James. "A Model for Forest Recreation and Timber Management Planning." Department of Landscape Architecture, Graduate School of Design, Harvard University, Cambridge, Mass., June, 1969 (unpublished).

53. Legault, R.R., and Polcyn, F.C. "Investigations of Multi-Spectral Image Interpretation." 3rd Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, 1964.

54. Leyland, George P. "Implications of the New Haven Census Use Test for Transportation and Land Use Planning. Presented at the Highway Research Board Meeting, Washingt D.C., January, 1968.

55. Loomis, R.G., and Lorenzo, J.J. "Experiments in Mapping with a Geo Space Plotter." Urban and Regional Information Systems for Social Programs. Papers from the 5th Annual Conference of the Urban and Regional Information Systems Association, Garden City, N.Y., September, 1967, pp. 219-233.

56. Lowry, Ira S. "A Short Course in Model Design." Journal of the American Institute of Planners. Vol. XXXI, No. 2, May, 1965.

57. Lueder, D.R. Aerial Photographic Interpretation: Principles and Application. McGraw-Hill Book Co., New York, N.Y., 1959.

58. Manual of Color Aerial Photography. American Society of Photogrammetry, Washington, D.C., 1968.

59. Manual of Photographic Interpretation. American Society of Photogrammetry, Washington, D.C., 1960.

60. Maps and Computers. Metropolitan Planning Commission, Portland, Oregon, June, 1967.

61. McLerran, J.H. Infrared Sea Ice Reconnaissance. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

62. Minton, George, and Fasteau, Herman, H. Automated Geographic Coding System. 1963 Economic Censuses: Research Report No. 1, Operations Research, Economic Operations Division, U.S. Bureau of the Census, June, 1965.

63. Mintzer, O.W. "Photo Interpretation of Soils Using Color." Manual of Color Aerial Photography. American Society of Photogrammetry, 1968, Chapter 10.

64. Mintzer, O.W. "Remote Sensing for Engineering of Terrain-Photographic Systems." Ohio State University, Columbus, Ohio, 1968 (unpublished report).

65. Negroponte, Nicholas. "Urban Five: An On-Line Urban Design Partner." Presented at the First Annual International Conference of the Design Methods Group, Cambridge, Mass., June, 1968.

66. Nordbeck, Stig. "Coordinate Mapping Techniques." PLAN, Journal of Town and Country Planning. Vol. 22, Swedish Association of Town and Country Planning, 1968, pp. 101-117.

67. Nordbeck, Stig,and Rystedt, Bengt. Computer Cartography Point in Polygon Programs. Lund Studies in Mathematical Geography No. 7, Department of Geography, The Royal University of Lund, Sweden, 1967.

68. Nussbaum, E. "Automatic Plotting." Prepared for the Urban Planning Division, U.S. Bureau of Public Roads General Electric Information Service Department, Washington Computer Applications Office, Washington, D.C., February, 1967.

69. Nussbaum, E. "Automatic Plotting and Digitizing." Urban and Regional Information Systems for Social Programs. Papers from the Fifth Annual Conference of the Urban and Regional Information Systems Association, Garden City, N.Y., September, 1967, pp. 234-261.

70. *Oakland Planning Information System - User's Manual.* Prepared by Stanford Research Institute (W.K. Williams) for the City of Oakland, California, 701 Project Technical Report No. 1, September, 1967.

71. Parker, Dana C., and Wolf, Michael F. in *International Science and Technology*. July 1965.

72. Pfaltz, John L. "Manipulation and Display of Geographically Distributed Data." Paper presented at the Third Technical Conference of the Council of Social Science Data Archives, Ann Arbor, Michigan, May, 1966.

73. Rib., H.T. *An Optimum Multisensor Approach for Detailed Engineering Soils Mapping.* 2 Vols. Joint Highway Research Project, Report No. 22, Purdue University, Lafayette, Indiana, 1966.

74. Rens, Frank J. *A Fortran Program for Coordinate Mapping Using an IBM 7090 Computer.* University of Michigan, Ann Arbor, Michigan, February, 1965. (Also AD 611754)

75. Schmidt, Allan. *A Report on the Feasibility of Using Computer Mapping Techniques as an Aid in the Processing of Mortgage Insurance Applications.* Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., July, 1967.

76. Schmidt, Allan. "Computer Graphics and Urban Information Systems." In *Report of Summer Studies Program II.* Urban Systems Laboratory, Massachusetts Institute of Technology, July, 1968.

77. "Select Papers on Remote Sensing." *Selected Proceedings of the Third Conference on Remote Sensing.* American Society of Photogrammetry, Ann Arbor, Michigan, 1968.

78. Shepard, Donald S. "A Load-Shifting Model to Reduce Exposure to Air Pollution Caused by Electric Power Generation." Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., June, 1969 (unpublished paper).

79. Simon, Herbert A. *The New Science of Management Decision* Harper and Row, New York, 1960.

80. Simons, J.H. "Some Applications of Side-Looking Airborne Radar." Paper written for Contract AN/APQ-56, Raytheon Company, Alexandria, Virginia.

81. Steiner and Haefner. "Grey Tone Distortion on Aerial Photographs - A Problem for the Quantified and Automated Photointerpretation of Terrain Cover Types." Paper presented at the 30th Annual Meeting of the American Society of Photogrammetry, 1964.

82. Struble, R.A. and Mintzer, O.W. "Combined Investigation Techniques for Procuring Highway Design Data." Proceedings of the 18th Annual Highway Geology Symposium, Purdue University, Lafayette, Indiana, 1967.

83. Thomas, Adrian L. OBLIX, A Computer Program, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., 1969 (unpublished paper).

84. Tobler, W.R. "Numerical Map Generalization and Notes on the Analysis of Geographical Distributions." Discussion Paper No. 8, Michigan Inter-University Community of Mathematical Geographers, Department of Geography, University of Michigan, Ann Arbor, Michigan.

85. Tomlinson, Roger F. An Introduction to the Geographic Information System of the Canada Land Inventory. ASP-ACSM Annual Convention, Washington, D.C., March 7, 1967.

86. Tomlinson, R.F. An Introduction to the Geographic Information System of the Canada Land Inventory. Department of Forestry and Rural Development, Ottawa, Canada, 1967.

87. Urban Atlas. Census Use Study, Bureau of the Census, Suitland, Maryland, December, 1968.

88. Using Computer Graphics in Community Renewal. Community Renewal Program Guide No. 1, Urban Renewal Administration, Housing and Home Finance Agency, Washington, D.C., January, 1963.

89. Richard C. Allison and Roger Leighton

1. Allison, Richard C. and Leighton, Roger S. *Evaluatin Forest Campground Sites*. Extension Folder 54, Cooperative Extension Service, University of New Hampshire, Durham, New Hampshire.

90. Chester County Planning Commission

1. *Natural Environment and Planning*. Chester County Planning Commission. West Chester, Pa., July, 1963.

91. C.S. Christian

1. Christian, C.S. *Aerial Surveys and Integrated Studie* Proceedings of the Toulouse Conference, 1964, UNESCO 1968.
2. ________. *The Concept of Land Units and Land System* Proceedings of the Ninth Pacific Science Congress, Vol. 20, 1958, pp. 74-81.
3. ________, Jennings, J.N., and Twidale, C.R. *Guidebook to Research Data for Arid Zone Development*. Arid Zone Research, VIII. Paris, UNESCO, 1957, pp. 51-65.
4. ________, and Perry, R.A. "The Systematic Description of Plant Communities by the Use of Symbols." *Journal of Ecology*. Vol. 41, 1953, pp. 100-105.
5. ________, and Stewart, G.A. *General Report on Survey of the Katherine-Darwin Region 1946*. Aust. Land Res., Ser. No. 1, 1953.
6. ________, and Stewart, G.A. *North Australia Regiona Survey, 1946, Katherine-Darwin Region: General Repor on Land Classification and Development of Land Industries*. CSIRO, Melbourne, 1947 (mimeo).

92. John A. Dearinger

1. Dearinger, John A. *Esthetic and Recreational Potenti of Small Naturalistic Streams Near Urban Areas*. University of Kentucky, Water Resources Institute, Lexington, Kentucky, 1968.

93. G. Angus Hills

1. Hills, G. Angus. *Definitions: Ecological Basis of Land-Use Planning.* Unpublished mimeo for class use, October, 1966.

2. ________. "The Classification and Evaluation of Land for Multiple Uses." *Forestry Chronicle.* June, 1966.

3. ________. *Ranking the Recreational Potential of Land Units by Gradient Analysis; a Physiographic Classification of Land for Recreational Use.* Proceedings of the National Meeting on Land Capability Classification for Outdoor Recreation, Ottawa, February 23 and 24, 1966.

4. ________. *Definition of Capability Classes and Benchmark Sites for the Recreational Land Inventory.* Unpublished mimeo, January 21, 1966.

5. Hills, G.A., and Pierpoint, G. *The Land Resources of the Sunbury Basin.* Technical Series No. 50. Department of Lands and Forests, Ontario, November, 1963.

6. ________. *The Ecological Basis for Land-Use Planning.* Research Report No. 46. Ontario Department of Lands and Forests, Toronto, 1961.

7. ________, and Portelance, R. *The Glackmeyer Report of Multiple Land-Use Planning.* Ontario Department of Lands and Forests, Toronto, 1960.

8. ________. *The Classification of Lands in Ontario According to their Potential for Agricultural Production in an Economy of Multiple Land-Use.* Ontario Department of Lands and Forests, Maple, 1956.

9. ________. "The Use of Aerial Photography in Mapping Soil Sites." *Forestry Chronicle.* Vol. 26, No. 1, 1950, pp. 4-37.

10. Hills, G. Angus. *The Classification of Northern Ontario Lands According to their Potential for Agricultural Production.* Soil Report No. 1. Research Division, Ontario Department of Lands and Forests, Toronto, 1949.

94. Philip H. Lewis, Jr.

1. **Lewis, Philip H.** *Regional Design for Human Impact.* Prepared for the U.S. Department of the Interior, National Park Services, Northeast Region. Madison, Wisconsin, November, 1967.

2. ________. "Environmental Awareness." In *Arts in Society*, University Extension, University of Wisconsin 1967, pp. 477-490.

3. ________, (Consultant). *The Outdoor Recreation Plan.* Wisconsin Development Series, Department of Resource Development, Madison, Wisconsin, 1966.

4. ________. "Environmental Design Concepts for Open Space Planning in Minneapolis and its Environs." University of Illinois: *Parks and Recreation in Minneapolis*, Vol. III, Minneapolis Board of Park Commissioners, December, 1965.

5. **Lewis, Philip H.** "Quality Corridors for Wisconsin." *Landscape Architecture Quarterly*, January 1964, pp. 100-107.

6. ________. "Landscape Resources." *Wisconsin Blue Book.* 1964.

7. ________. *Landscape Analysis I: Lake Superior South Shore Area.* Wisconsin Department of Resource Development, Madison, 1963.

8. ________. *Recreation in Wisconsin.* Wisconsin Department of Resource Development, Madison, 1962.

9. ________. *Recreation and Open Space in Illinois.* University of Illinois Department of Landscape Architecture and Bureau of Community Planning, Urbana, 1961.

95. R. Burton Litton, Jr.

1. Litton, R. Burton, Jr. *Forest Landscape Description and Inventories: a basis for planning and design.* Research Paper PSW-49, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Berkeley, California, 1968.

96. Ian L. McHarg

1. McHarg, Ian L. *Design with Nature.* Natural History Press, Garden City, New York, 1969.

96. Ian L. McHarg (cont'd.)

2. ________. "Where Should the Highway Go?". Landscape Architecture. Vol. 57, No. 3, 1967.

3. Wallace-McHarg, Associates. A Memorandum on a Method for Undertaking a Comprehensive Plan for the Hudson River Basin. Unpublished professional proposal. 1967 (32)

4. McHarg, Ian L. "An Ecological Method for Landscape Architecture." Landscape Architecture, Vol. 57, No. 2, 1967.

5. Wallace, McHarg, Roberts, and Todd. Towards a Comprehensive Landscape Plan for Washington, D.C. Prepared for the National Capital Planning Commission, April, 1966. (97)

6. McHarg, Ian L. "Ecological Determinism." F. Fraser Darling and John D. Milton, eds. Future Environments of North America. April, 1965, pp. 526-538.

7. ________. Metropolitan Open Spaces from Natural Processes. University of Pennsylvania, Philadelphia, 1964.

8. Wallace-McHarg Associates. Plan for the Valleys. Philadelphia, Pennsylvania, 1963.

97. PARIS, The State of California

1. Outdoor Recreation Outlook to 1980. Monograph #5. Sacramento Metropolitan Area, State of California, Resources Agency, Department of Parks and Recreation, October, 1967.

2. Outdoor Recreation Outlook to 1980. Monograph #4. San Diego Metropolitan Area, The Resources Agency, Department of Parks and Recreation, July, 1967.

3. "California Parkways -- a Plan for a State System." Preliminary Report, State of California, The Resources Agency, Department of Parks and Recreation.

4. Outdoor Recreation Outlook to 1980. Monograph #3. San Francisco Bay Area Metropolitan Complex, State of California, Resources Agency, Department of Parks and Recreation.

97. PARIS, The State of California (cont'd.)

5. Park and Recreation Information System (PARIS). Planning Monograph #2. State of California, The Resources Agency, Department of Parks and Recreation, November, 1966.

6. Outdoor Recreation Outlook to 1980. Monograph #1. Los Angeles Metropolitan Complex, State of California, The Resource Agency, Department of Parks and Recreation, June, 1966.

98. RECSYS, The State of Michigan

1. Outdoor Recreation Planning in Michigan. Technical Report No. 12. "The Practical Application of Program RECSYS and SYMAP." The State Resources Planning Program, Department of Commerce, State of Michigan, December, 1967.

2. Outdoor Recreation Planning in Michigan. Technical Report No. 7. "Computer Mapping for Recreation Planning." The State Resources Planning Program, Department of Commerce, State of Michigan, August, 1966.

3. Michigan Outdoor Recreation Demand Study. Technical Report No. 6, Vol. I. "Method and Models", The State Resource Planning Program, Department of Commerce, State of Michigan, 1966.

4. Michigan Outdoor Recreation Demand Study. Technical Report No. 6, Vol. 2. "Activity Reports", The State Resource Planning Program, Department of Commerce, State of Michigan, 1966.

5. Outdoor Recreation Planning in Michigan. Technical Report 1. "A Manual for Program RECSYS." The State Resource Planning Program, Department of Commerce, State of Michigan, May, 1966.

99. Soil Conservation Service: 1

1. Soil Survey, Indiana County, Pennsylvania. U.S. Soil Conservation Service, U.S. Department of Agriculture, January, 1968.

2. Appraisals of Potentials for Outdoor Recreation Developments. SCS, USDA, July, 1966.

99. Soil Conservation Service: 1 (cont'd.)

3. Engineering Soil Classification for Residential Developments. Compiled and edited by the Federal Housing Administration, 1961.

4. Soil Classification: a Comprehensive System. Soil Conservation Service, USDA, 1960.

5. Diagnosis and Improvement of Saline and Alkali Soils. USDA Handbook 60, 1954, 160 pp., illus.

6. Uhland, R.E., and O'Neal, A.M. Soil Permeability Determinations for Use in Soil and Water Conservation. SCS Tech. Paper 101, 1951, 36 pp., illus.

7. Soil Survey Manual. USDA Handbook #18. 1951.

100. Soil Conservation Service: 2

1. Guide to Making Appraisals of Potentials for Outdoor Recreation Developments. SCS, USDA, July, 1966.

101. Steinitz Rogers Associates Inc.

Jacobs, Peter
Murray, Timothy
Rogers, Peter
Sinton, David
Steinitz, Carl
Toth, Richard
Way, Douglas

1. Jacobs, Peter, and Way, Douglas. Visual Analysis of Landscape Development. Harvard Graduate School of Design, Department of Landscape Architecture, Cambridge, Mass., 1968.

2. _________, and Way, Douglas. Visual Analysis of Landscape Development. Canadian Architect, May, 1968.

3. _________, and Way, Douglas. How Much Development Can Landscape Absorb. Landscape Architecture Quarterly, July, 1969.

4. Jacoby, H., Questor, G., and Rogers, P. Public Investment: Economics, Politics, and Systems Analysis. (In preparation)

101. Steinitz Rogers Associates Inc.

5. Pyatt, E.E., and Rogers, P. "On Estimating Benefit-Cost Ratios for Water Supply Investments." *American Journal of Public Health*, Vol. 52, No. 10, October, 1962, pp. 1729-1742.

6. Pyatt, E.E., Rogers, P., and Sheikh, H. "Benefit-Cost Analysis for Municipal Water Supplies." *Land Economic*, Vol. 40, No. 4, November, 1964, pp. 444-449.

7. Rogers, P. "A Systems Analysis of the Lower Ganges-Brahmaputra Basin." Presented at the UNESCO Conference in Leningrad, August, 1967. To be published in conference proceedings.

8. ________. "The Role of Optimizing Model in Resource Planning." In *Seminar on Water Resources Development*, The World Health Organization and the Pan American Health Organization (Ven-6400, Document 23), Venezuela, 1968.

9. ________, and Smith, D.V. "An Algorithm for Investigation Project Planning." December,1968.

10. ________, Sinton, D., and Russell, C. "A Modified Rational Method for Estimating Storm Run-Off in Urbanizing Areas." In *Qualitative Values in Environmental Planning, A Study of Resource Use in an Urbanizing Watershed*, Rogers, P. and Steinitz, C., U.S. Army Corps of Engineers, Research Contract DACN33-68-C-0151, Graduate School of Design, Harvard University, Cambridge, Mass., 1969.

11. ________. "Some Aspects of Mathematical Models of Water Resources Systems." In *Lectures on Water Management*, Melvin E. Scheidt (ed.), The Johns Hopkins University, Baltimore Maryland, 1965, Chapter 16.

12. Sinton, David, and Steinitz,Carl. *GRID, a Computer Program*, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., 1967.

13. ________. *The Role of Maps in the Decision Making Process*. Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., 1967.

101. Steinitz Rogers Associates Inc. (cont'd.)

14. Sinton, D. FLOWS and VIEWS, Two Computer Programs with Spatial Searching Capabilities, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., 1969. (Unpublished)

15. Steinitz, Carl. Computers and Regional Planning: The DELMARVA Study. Graduate School of Design, Harvard University, Cambridge, Mass., 1967.

16. ________. "The Congruence of Urban Form and Activity." Journal of the American Institute of Planners, July, 1968.

17. ________. "The Hudson River Water Quality Study." Landscape Architecture Quarterly, January, 1968.

18. Sinton, D. and Belcher, D., et al. New York State Natural Resources Inventory. Office of Planning Coordination, The State of New York, 1968.

19. ________, and Rogers, P. A Systems Analysis Model of Urbanization and Change: An Experiment in Interdisciplinary Education. Harvard Graduate School of Design, October, 1968. Publication pending, M.I.T. Press, May, 1970.

    Abstracted in EKISTICS, Volume 28, No. 164, July, 1969.

20. ________. "Regional Planning and Computer Graphics." In Computer Graphics in Architecture and Design, M. Milne (ed.), Yale University, New Haven, Conn., 1969.

21. Steinitz, C., ed. Computer Graphics and Spatial Analysis: Selected Projects. Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, Cambridge, Mass., 1969.

22. ________, Murray, T., Sinton, D., and Way, D. A Comparative Evaluation of Resource Analysis Methods. U.S. Army Corps of Engineers, Research Contract DACW33-68-C-0152, Harvard University, Graduate School of Design, Cambridge, Mass., 1969.

23. ________, and Rogers, P. Qualitative Values in Environmental Planning, A Study of Resource Use in Urbanizing Watersheds. U.S. Army Corps of Engineers, Research Contract DACW33-68-C-0151, Harvard University, Graduate School of Design, Cambridge, Mass., 1969.

101. Steinitz Rogers Associates Inc. (cont'd.)

24. Swanson, R. Land Use and Natural Resources Inventory. New York State, Office of Planning Coordination Staff Papers, Albany, N.Y., June, 1969.

25. Thomas, H.A., Jr., and Burden, R.P., (eds.) Operations Research in Water Quality Management. (Harvard Water Resources Group, Final Report to the Bureau of State Services, Division of Water Supply and Pollution Control: Public Health Service, February, 1963), Chapter 6.

26. Way, Douglas. Air Photo Interpretation for Land Planning. Department of Landscape Architecture, Graduate School of Design, Harvard University, Cambridge, Mass., 1968.

102. Richard Toth

1. Toth Richard. "Criteria for Evaluating the Valuable Natural Resources of the TIRAC Region." Stroudsburg, Pennsylvania, Tocks Island Regional Advisory Council, 1968.

2. Spreiregen, Paul. "Tocks/Calumet." Landscape Architecture Quarterly, October, 1968, pp. 30-35.

103. Edward A. Williams

1. Williams, Edward A. Open Space: the Choices Before California -- the Urban Metropolitan Open Space Study. San Francisco, Diablo Press, 1969.

104. Ervin Zube, and Research Planning and Design Associates

1. Research Planning and Design Associates, Incorporated, Amherst, Massachusetts. Study of Visual and Cultural Environment, Visual Landscape Quality Constraints. Prepared for the North Atlantic Regional Water Resources Study Coordinating Committee, November, 1968.

2. Department of Landscape Architecture, University of Massachusetts, Ervin Zube, Chairman. The Islands -- Selected Resources of the United States Virgin Islands. Washington, D.C., United States Department of the Interior, January, 1968.

3. Research Planning and Design Associates, Incorporated, Amherst, Massachusetts. Study of Visual and Cultural Environment (Preliminary). Prepared for the North Atlantic Regional Water Resources Committee, November, 1967.

104. Ervin Zube, and
Research Planning and Design Associates (cont'd.)

4. Cooperative Extension Service, University of Massachusetts and United States Department of Agriculture, Ervin Zube, Project Head. Selected Resources of the Island of Nantucket, Amherst, Massachusetts, 1967.

APPENDIX A

APPENDIX A.1

CONGRUENCE AND MEANING: THE INFLUENCE OF CONSISTENCY BETWEEN URBAN FORM AND ACTIVITY UPON ENVIRONMENTAL KNOWLEDGE 1966-1967

Principal Investigator: Carl Steinitz
Sponsors: Joint Center for Urban Studies, M.I.T. - Harvard
Department of City and Regional Planning, Massachusetts
Institute of Technology

The research investigated environmental meaning. It attempted to demonstrate that there are measurable correspondences -- congruences -- between urban form and activity, and that the regularities in these relationships have a major influence on the amounts and kinds of meanings which the environment transmits and which people can acquire. The effectiveness of the environment in transmitting meaning was hypothesized to be a function of its environmental characteristics -- of the form and activity attributes and the congruence between them. Predictions were made about the influences of congruences between form and activity types, between the visual intensity of forms and the busyness of activities, and between the exposure of forms and the importance of activities. Predictions were also made about the effects of various personal characteristics -- such as social class, sex, familiarity, travel mode and place of residence -- on the extent and complexity of environmental knowledge.

A two-stage research method was devised to test the hypotheses. First, a survey was made of form and activity characteristics of the study area, and their congruences were analyzed. Then interviews were conducted to investigate what a controlled sample of people know about these environmental attributes. The research method made extensive use of computer facilities.

Figure A.1.1 displays data on open space and building height, collected on the basis of a one acre grid (approximately 1/250 square kilometer). [See Steinitz, (101.16)]

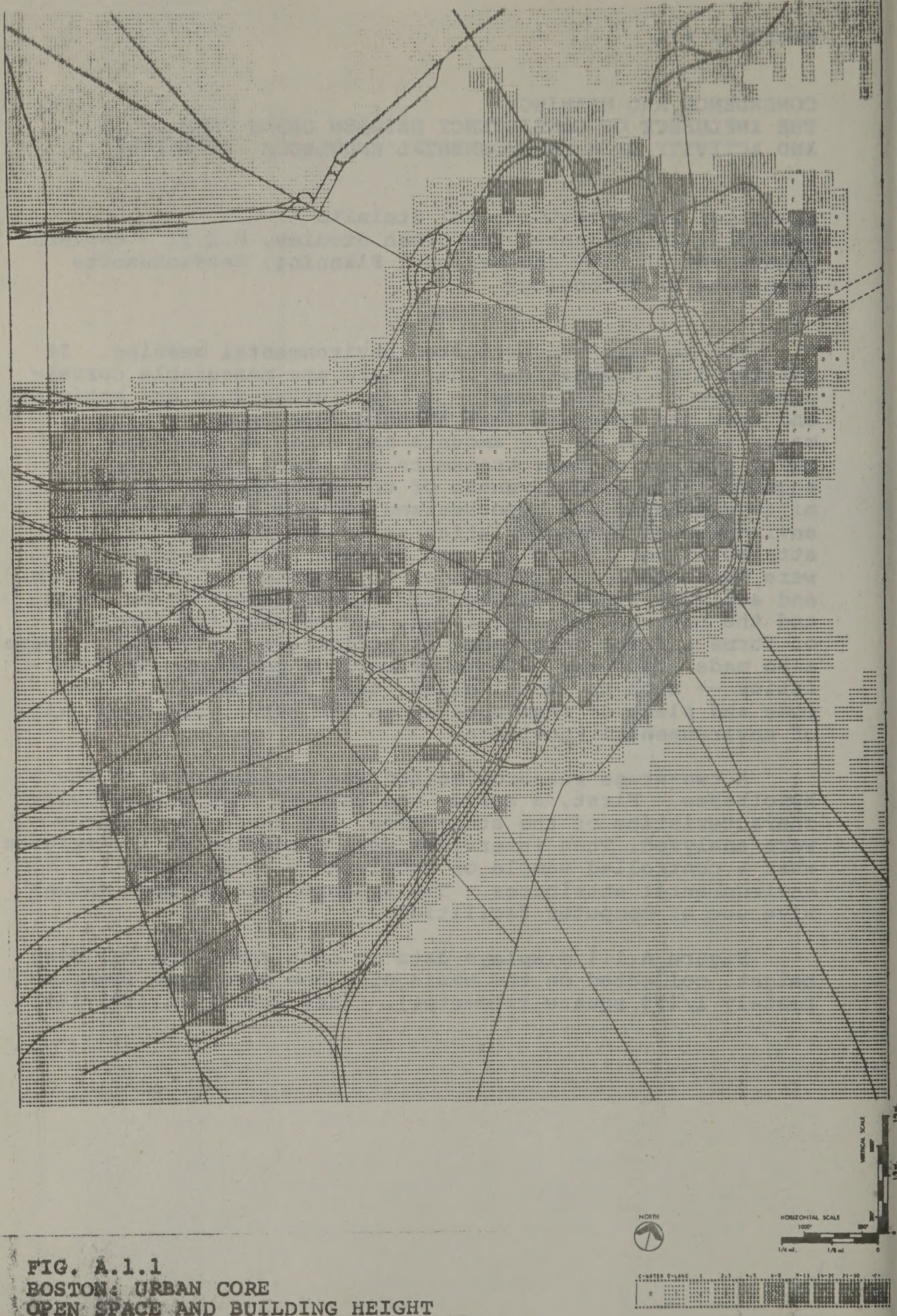


FIG. A.1.1
BOSTON: URBAN CORE
OPEN SPACE AND BUILDING HEIGHT

APPENDIX A.2

EXURBAN DEVELOPMENT STUDY 1968-1969

Principal Investigators: John Gaffney, Harry Garnham, Nicholas Quennell
Consultants: Peter Jacobs, David Sinton, Carl Steinitz
Sponsor: Department of Landscape Architecture, Harvard Graduate School of Design

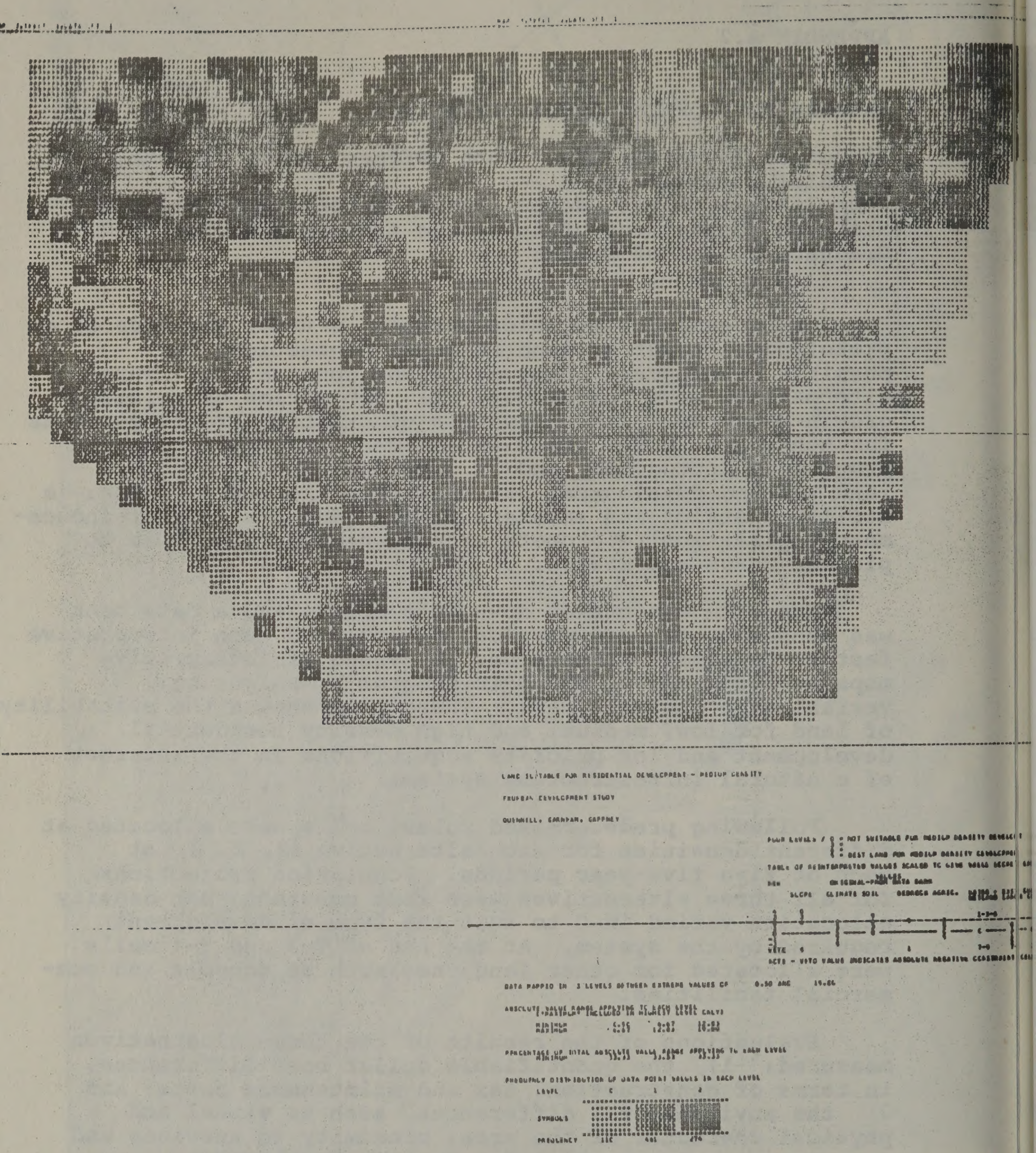
Using gaming simulation methods, a study was made of a prototypical tract of land in rural Connecticut for possible development under different constraints. Three alternatives were postulated: 1) projection of existing growth patterns; 2) projection of existing growth patterns for ten years, after which an easement and sewer district program is introduced; and 3) assumption of control of land use and development patterns from the start, using: a utility district and easement program and a system of inducement legislation to promote grouped development close to planned roads and sewers.

The site was broken down into cells, and a data bank was prepared of basic physical factors and such interpretive factors as visual absorption. A series of interpretive maps was produced by the GRID program by weighting variables in the data bank. These maps showed the suitability of land for low, medium, and high density residential development and for priority acquisitions in the interest of a natural infrastructure system.

Following predetermined rules, cells were allocated at different densities for each alternative (1, 2, 3) at each of five five-year periods. Population projections for all three alternatives were kept constant, but density allocation varied in C to suit the type of development required by the system. At the end of T-3 and T-4 cells were allocated for other land uses such as schools and commercial facilities.

Evaluations of the results of the three alternatives measured: 1) the quantifiable dollar cost differences, in terms of construction, tax and maintenance costs; and 2) the environmental differences, such as visual and physical character of the area, proximity to services and open space, and potential for further development.

Figure A.2.1 shows the areas suitable for middle density residential development in the 50 square kilometer study area. The data were collected and evaluated on the basis of a 1/25 square kilometer grid, an area of about 10 acres.



LAND SUITABLE FOR RESIDENTIAL DEVELOPMENT - MEDIUM DENSITY

EXURBAN DEVELOPMENT STUDY

QUENNELL, GARNHAM, GAFFNEY

FIG. A.2.1 N. Quennell, H. Garnham,
J. Gaffney

EXURBAN DEVELOPMENT STUDY
LAND SUITABLE FOR RESIDENTIAL
DEVELOPMENT
MEDIUM DENSITY

APPENDIX A.3

BOSTON: METROPOLITAN CORE Fall 1968

Project Directors: Carl Steinitz and David Sinton
Associate: Peter Jacobs
Students: D. Boonkham, G. Bressler, E. Chism, D. Collins, R. Erickson, J. Dangermond, Mrs. S. Dworsky, B. Erickson, Miss S. Gallaudet, G. Gumz, G. Gund, R. Hester, T. Kirvan, R. Mayer, T. Nelson, C. Norris, J. Pike, W. Reynolds, R. Scheele, Mrs. P. Loheed, V. Walker, C. Weber, F. Wing
Sponsor: Course, Department of Landscape Architecture, Harvard Graduate School of Design

A data bank describing the Boston Metropolitan core has been one product of a new series of interrelated introductory courses that are required of incoming students in the Department of Landscape Architecture.

In parallel with an introductory course on aerial photographic interpretation conducted by Mr. Douglas Way, students were introduced to several packaged computer programs which could be adapted for a variety of analytic and display requirements. They were also taught a basic level Fortran IV. Aerial photographic interpretation and other means were then used to develop the data bank which the students programmed for a series of analytic tasks and displays of their own choice.

The Boston: Metropolitan Core data bank was based upon a 1/9 square kilometer UTM grid, an area of about 25 acres. The study area was described in approximately 6000 cells.

Figure A.3.1 showed the maintenance quality of the open spaces and recreation facilities in the study area.

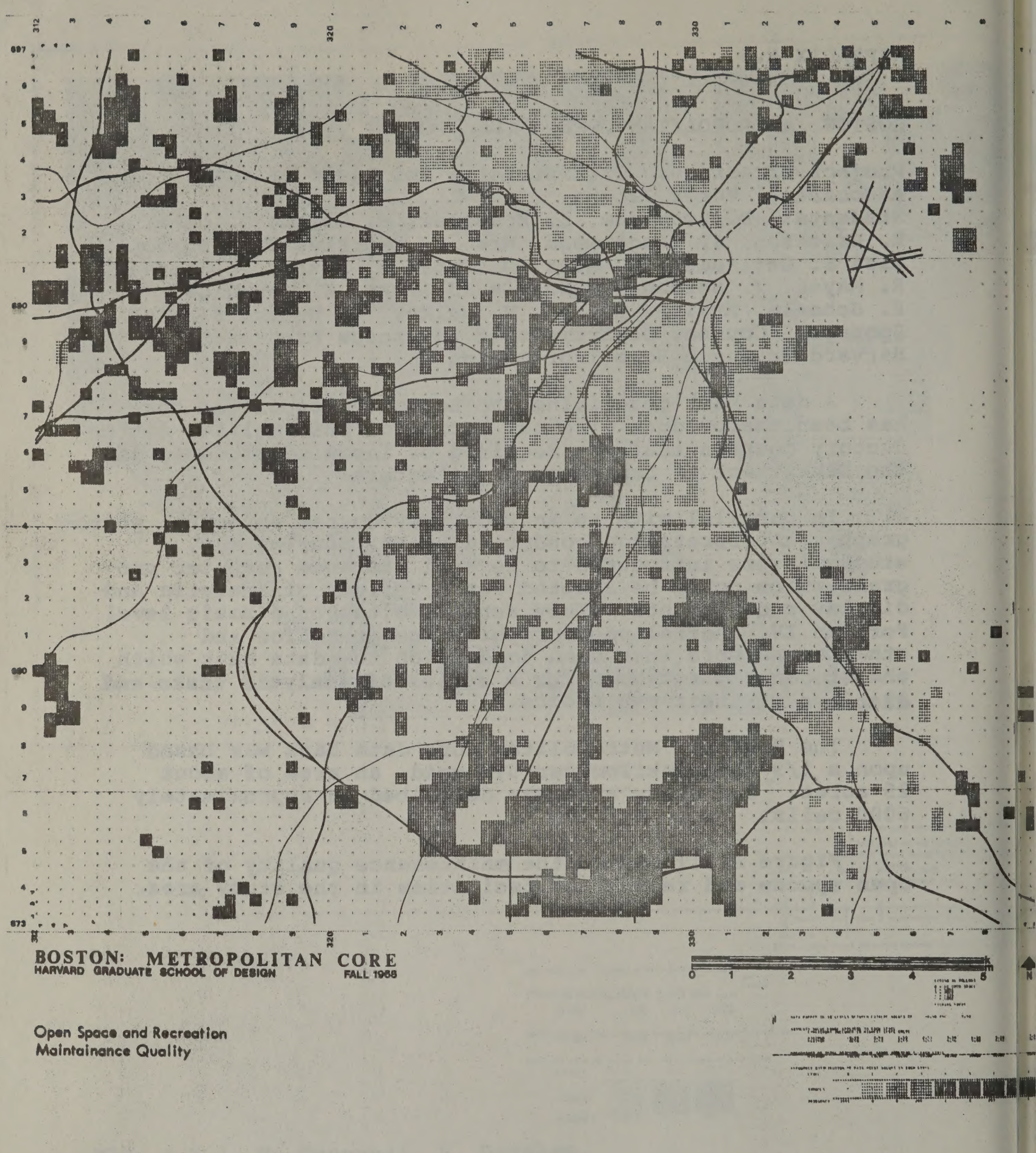

BOSTON: METROPOLITAN CORE
HARVARD GRADUATE SCHOOL OF DESIGN
FALL 1968
Open Space and Recreation
Maintainance Quality
312
320
330
687
673
0
1
2
3
4
5
N

FIG. A.3.1
BOSTON: METROPOLITAN CORE
OPEN SPACE AND RECREATION MAINTENANCE QUALITY

APPENDIX A.4

NEW YORK STATE LAND USE AND NATURAL RESOURCES INVENTORY 1967-1968

Project Director: Carl Steinitz
Associate: David Sinton
Sponsor: Office of Planning Coordination, State of New York, via Center for Aerial Photographic Studies, Cornell University, Donald J. Belcher, Director

For a land use and natural resources inventory of the State of New York, two separate but linked formats have been developed. First, a mapping format was developed for the entire state on the basis of census and other administrative divisions. A variety of statistical data were mapped to illustrate potential uses of the system to various state agencies.

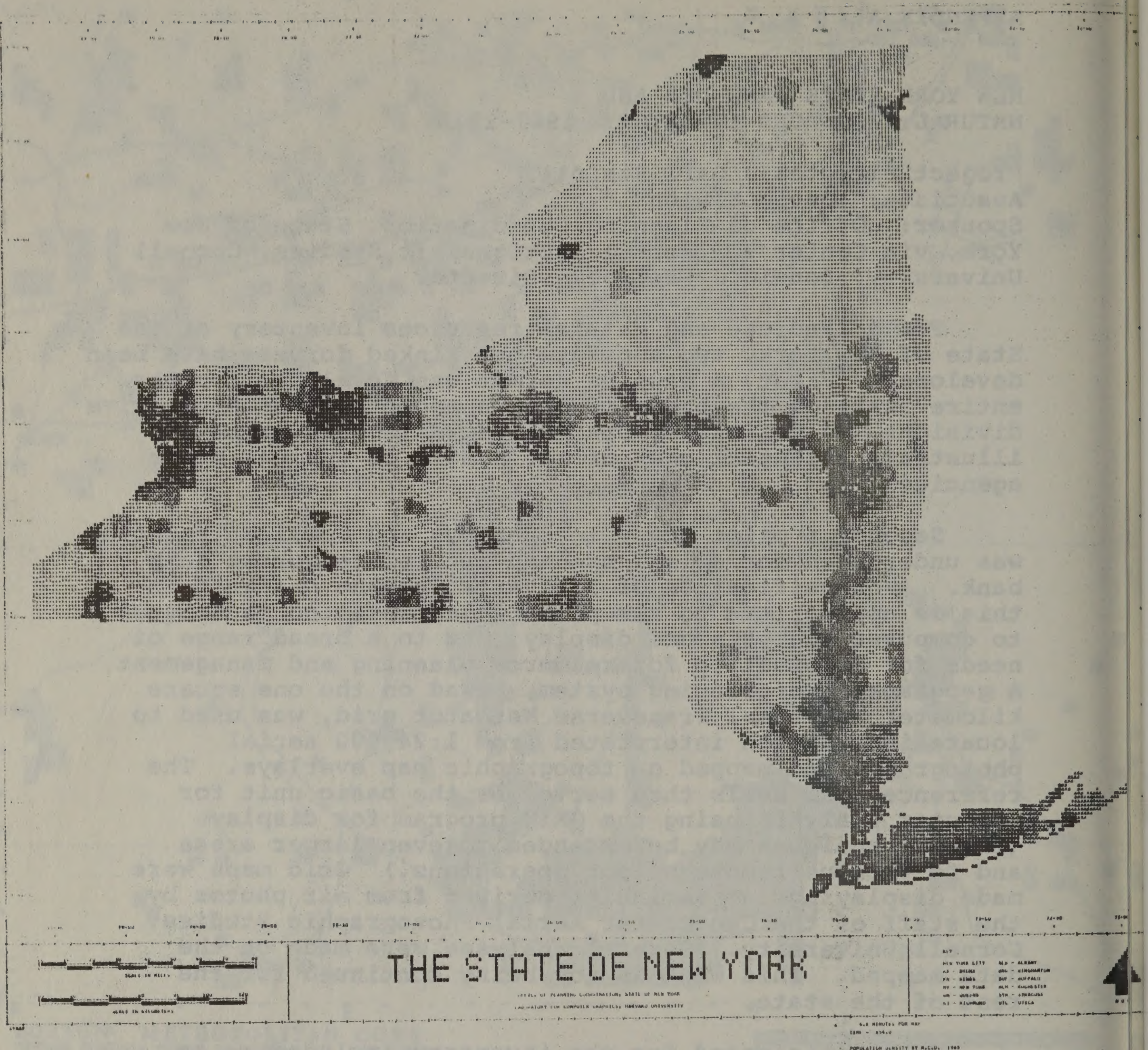
Second, a pilot study in Onandaga and Cortland counties was undertaken for a land use and natural resources data bank. A classification of 135 variables was designed; this is appropriate to air photo interpretation techniques, to computer analysis and display, and to a broad range of needs for information for resource planning and management. A geographic referencing system, based on the one square kilometer Universal Transverse Mercator grid, was used to locate information interpreted from 1:24,000 aerial photographs and mapped on topographic map overlays. The reference grid cells then served as the basic unit for computer analysis using the GRID program for display. (These techniques may be extended to even larger areas and to various remote sensor operations.) Grid maps were made displaying the variables derived from air photos by the staff of the Center for Aerial Photographic Studies, Cornell University. Several analyses were made on the data mapped. This work is now being continued for the rest of the state.

Uses anticipated for the inventory included -- in addition to state-wide planning -- county and town planning, river basin and watershed planning, analysis programs of agencies of the U.S. Departments of Agriculture and Housing and Urban Devlopment, and incorporation into the programs of various other state and federal agencies. Up-dating on a five-year basis was suggested.

Figure A.4.1 shows the population density by minor civil divisions in 1965 mapped in the state-wide format.

Figure A.4.2 shows the active agricultural land in each one square kilometer cell of Cortland and Onandaga counties, the pilot study area. [See Steinitz, Sinton, and Belcher (101.18), and Swanson (101.24).]

147



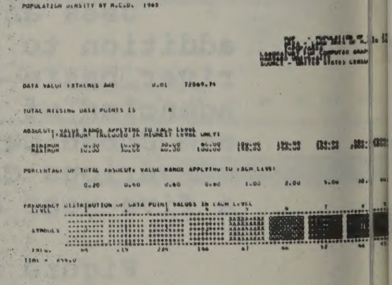


FIG. A.4.1
NEW YORK STATE
POPULATION DENSITY BY MINOR CIVIL DIVISIONS

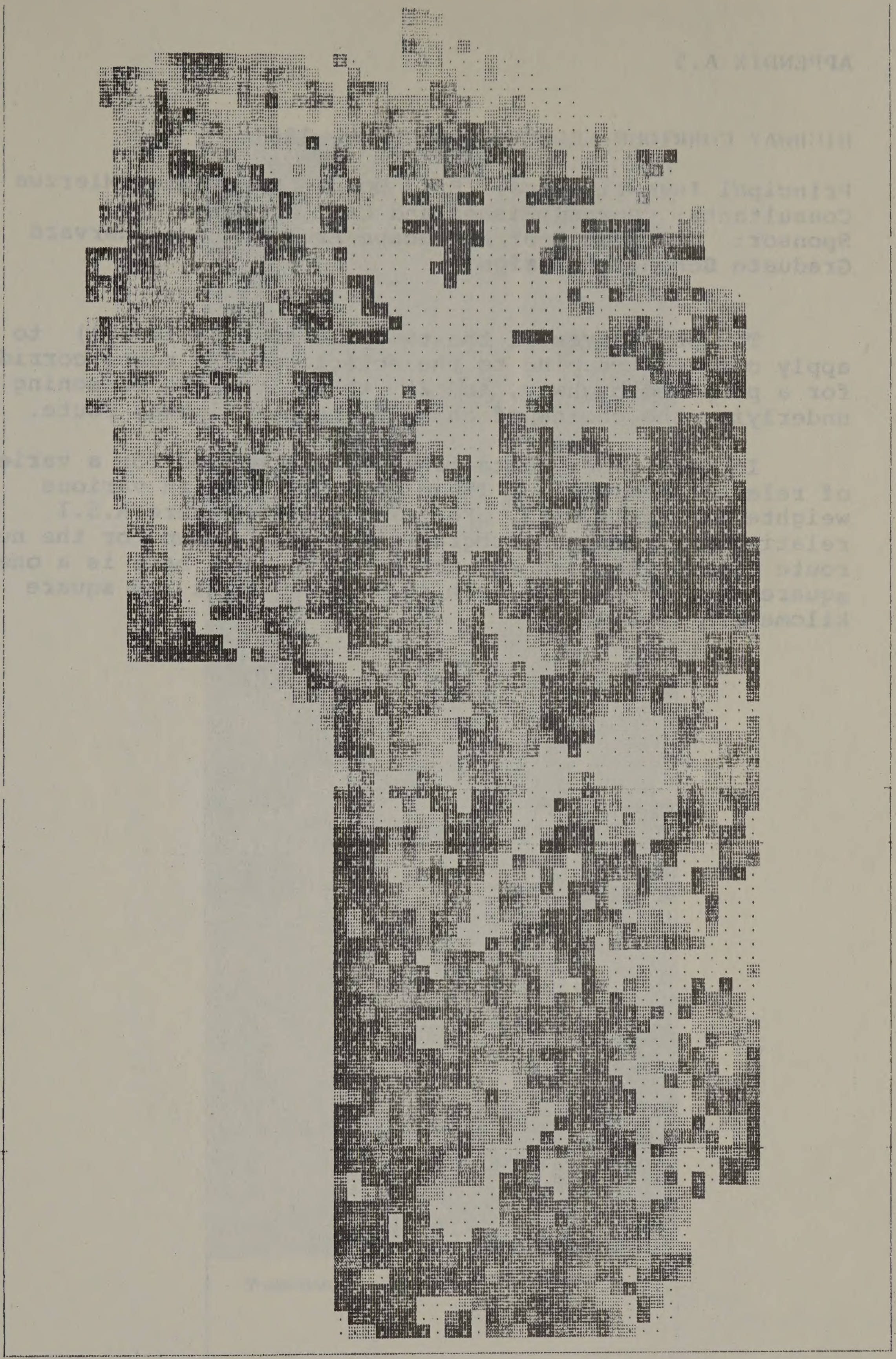

ACTIVE AGRICULTURAL LAND
AS A PERCENT OF TOTAL AGRICULTURAL LAND
SCALE IN KILOMETERS
SCALE IN MILES
NORTH
BLANK CELLS INDICATE THE ABSENCE OF THIS LAND USE
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
LEVEL
SYMBOLS
FREQUENCY

FIG. A.4.2
CORTLAND AND ONANDAGA COUNTIES
NEW YORK STATE
ACTIVE AGRICULTURAL LAND

APPENDIX A.5

HIGHWAY CORRIDOR SELECTION STUDIES 1967

Principal Investigators: Eric Doepke and Thomas Mierzwa
Consultants: Howard Fisher and Carl Steinitz
Sponsor: Department of Landscape Architecture, Harvard Graduate School of Design

The objectives of the two part study were: 1) to apply computer mapping to the selection of a route corridor for a proposed highway, and 2) to analyze the reasoning underlying the choice of an existing new highway route.

In both cases, data banks were prepared for a variety of relevant variables. These were combined in various weighted analysis maps. For example, in Figure A.5.1 relative pavement and subgrade costs are shown for the new route between the two end points. The data base is a one square mile grid, with each cell being about 2.6 square kilometers in size.

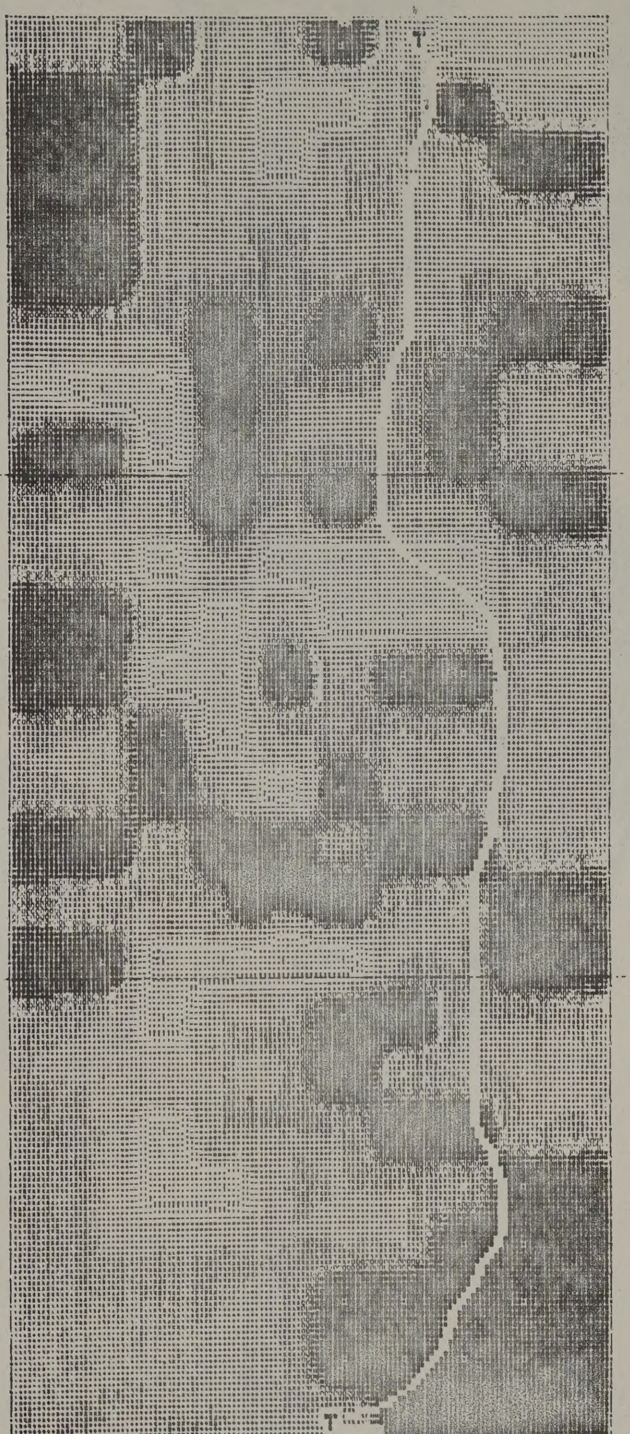


FIG. A.5.1 E. Doepke, T. Mierzwa
HIGHWAY CORRIDOR
SELECTION STUDY
RELATIVE PAVEMENT
AND SUBGRADE COSTS

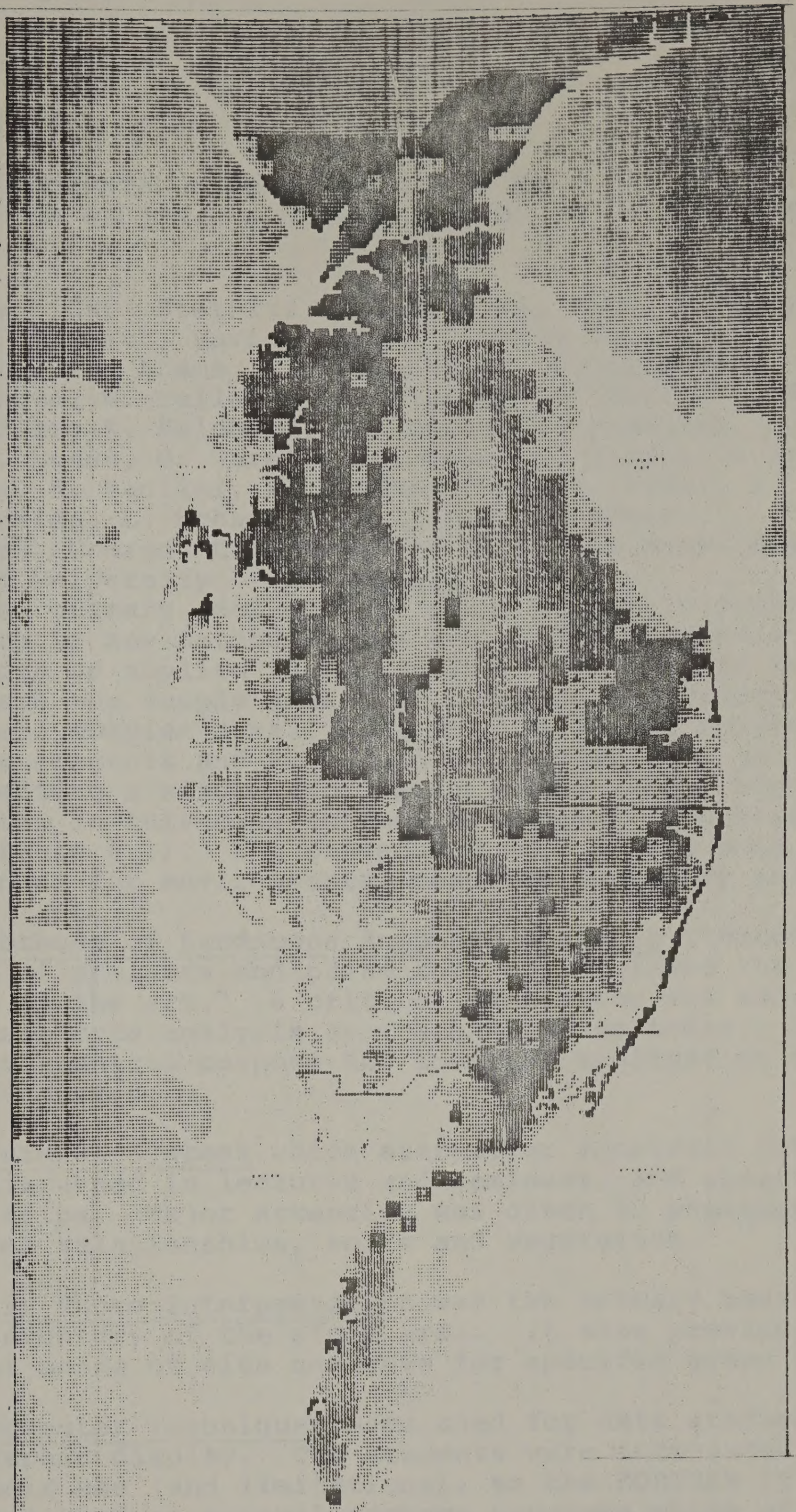


FIG. A.6.1
DELMARVA
AREAS FOR CONSERVANCY

APPENDIX B

APPENDIX B

AN ENVIRONMENTAL RESOURCE ANALYSIS OF THE BOSTON REGION: SOUTHEAST SECTOR (Fall 1969)

Faculty: Carl Steinitz, Douglas Way, Richard Toth, Frederick Smith, David Sinton, Timothy Murray
Students: T. Adams, P. Bochenek, A. Boutilier, J. Braun, S. Calhoun, W. Callaway, R. Clapper, H. Coffield, Miss S. Handler, K. Helphand, S. Jones, J. Kazanjian, J. Kelleher, Miss I. Maass, G. Marston, J. Mega, J. Olson, D. Orwig, D. Page, K. Paolini, R. Pomeroy, Miss V. Pratt, B. Thompson, B. Tsuchida, L. Urban, W. Williams, J. Zottu.
Sponsor: Course, Department of Landscape Architecture Harvard University

The primary goal of this study was to introduce students to new methodologies and advanced techniques which can be applied to the analysis of the land resources which are the supply aspect of planning and design for large and complex areas. The interrelations between the various concepts and skills to be covered were strengthened by selecting a single study area as the common basis of our work, in this case the Boston Region: Southeast Sector (see Figure B.1). The procedures demonstrate some aspects of a model for environmental resource inventory and analysis.

Methods of Landscape Resource Analysis, through a series of seminars and presentations, reviewed the analytic "state of the art." A critical evaluation was made of the major resource analysis approaches in use today. Criteria for both general purpose and specific application methods were discussed.

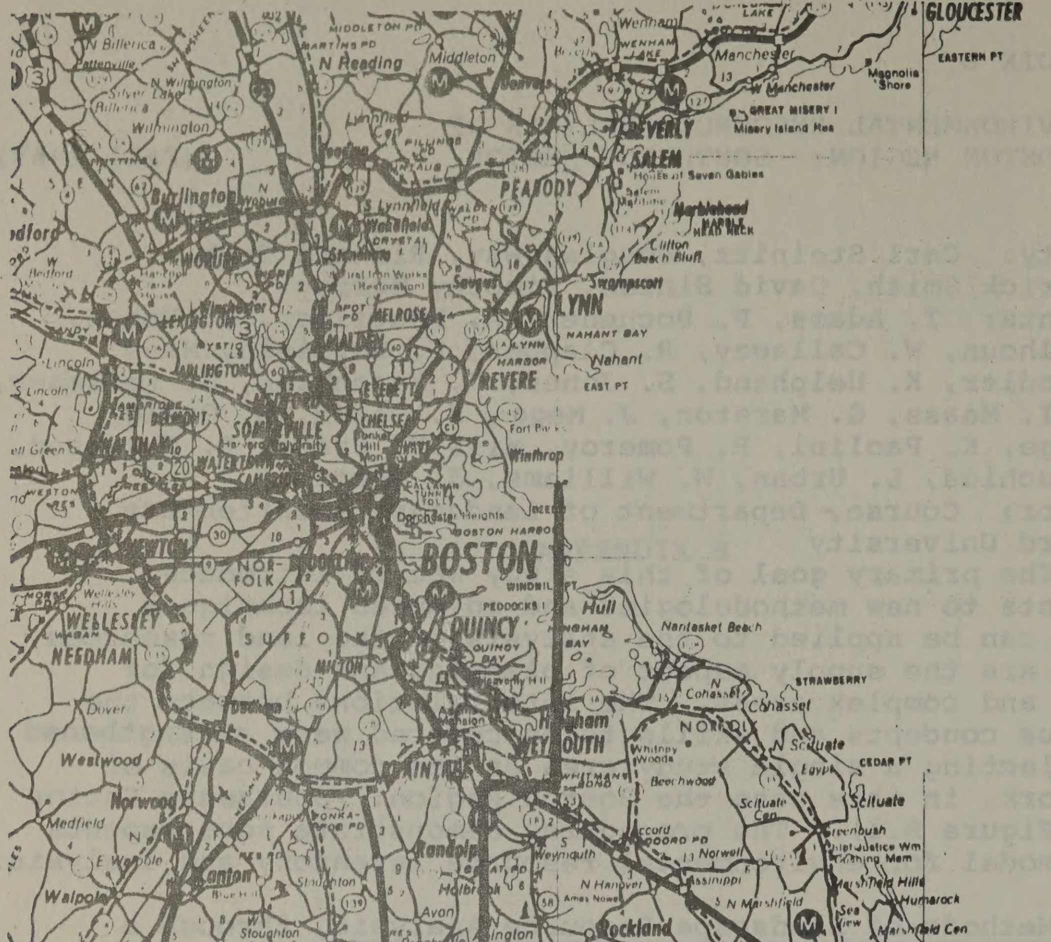
Natural Systems which attract or constrain development were discussed in lectures and seminars, and observed in field trips. Major attention was given to physiography, land-sea relationships, soils and vegetation.

Air Photo Interpretation was the primary basis for a data inventory of the study area. It also provided an efficient means of site analysis for specific areas of interest.

Computer Techniques were used for data storage, analysis and graphic display. The students were introduced to computers and their use (and limitations), to the FORTRAN IV programming language, and to several package programs which allowed them to use the computer in their analysis projects.

The descriptive data bank that was created by the students contained 76 variables for each of the 6136 grid cells that were in the study area. Each grid was 1/9th of a square kilometer (approximately 25 acres). Each of the data variables was internally scaled to a numerical code for ease of handling on digital computer. Two basic types

FIG. B.1 BOSTON REGION : SOUTHEAST SECTOR
REGIONAL CONTEXT



of scale were used in this data bank:

a--The percent of area of the grid cell in which the specified category occurs. This is a measure of the extent to which this particular category occurs within each grid cell. This type of scaling is used for those categories which usually require a finer scale of grid to accurately define the boundaries of their zones.

b-- The detailed type characteristic of the general category which predominates in that grid cell. This type of scale measures the particular subset of category which predominates in the grid cell.

With these criteria established, the scale of this grid was felt to be fine enough to adequately describe the zonal boundaries, so that there was no need to disaggregate them further. The variables that were included are listed below . Note that variables 71-73 are indexes to larger data zones which exist in the study area and variables 74-76 are locational variables.

The data bank was collected as part of student work in a course. It does not contain a consistent level of controlled quality which is expected from professional work. No guarantee can be given to the accuracy of the data or the resultant analysis. Each of the data variables was then mapped, using the GRID computer program. Figures B.2-B.23 present a selection of these data maps.

1. Topography - Elevation of Centroid of Cell
2. Topography - Orientation (Predominant Type in Cell)
3. Topography - % Area, 0-3% Slope
4. Topography - % Area, 3-6% Slope
5. Topography - % Area, 6-10% Slope
6. Topography - % Area, 10-15% Slope
7. Topography - % Area, 15%+ Slope
8. Bedrock - Depth
9. Landform - Predominant Type
10. Soil Type
11. Soil Moisture
12. Subsurface Water Depth
13. Water - % Area, Inland Water Bodies (lakes, reservoirs, ponds)
14. Water - % Area, Wetlands
15. Water - % Area, Rivers and Streams
16. Water - % Area, Ocean Including Estuary
17. Water - Predominant Type
19. Water Quality - Predominant
20. Shoreline Land Use - Predominant Type
21. Shoreline Access - Predominant Type
22. Physionomic Type - Predominant Type
23. Forest Cover - % Area, Deciduous
24. Forest Cover - % Area, Coniferous

25. Forest Cover - % Area, Scrub
26. Forest - Predominant Height
27. Forest - Predominant Density
28. Agriculture - % Area, Active Agriculture
29. Agriculture - % Area, Declining Agriculture
30. Agriculture - % Area, Old Fields
31. Developed Land - % Area
32. Residential - % Area, Farms or Estates
33. Residential - % Area, Single Family - Large Lot
34. Residential - % Area, Single Family - Medium Lot
35. Residential - % Area, Single Family - Small Lot
36. Residential - % Area, Multi-Family - Low Rise
37. Residential - % Area, Multi-Family - Middle Rise
38. Residential - % Area, Multi-Family - High Rise
39. Residential - Density
40. Residential - Predominant Maintainance Quality
41. Residential - Predominant Age of Development
42. Commerce - % Area, Shopping Centers
43. Commerce - % Area, Downtown Commerce
44. Commerce - % Area, Strip Commercial and Roadside Seri
45. Commerce - % Area, Wholesale Storage and Distributio
46. Commerce - % Area, Fuel and Material Storage and Distribution
47. Industry - % Area, Modern Industrial Parks
48. Industry - % Area, Old Industrial Complexes
49. Industry - % Area, Extractive Industries
50. Industry - % Area, Individual Industries
51. Public and Semi-Public Land - % Area
52. Public and Semi-Public Land - Predominant Type
53. Recreation - % Area
54. Recreation - Predominant Type
55. Recreation - Outdoor Facilities
56. Recreation - Cultural Facilities
57. Recreation - Commercial Facilities
58. Transportation - % Area
59. Transportation - Air and Rail, Major Type
60. Transportation - Road, Major Type
61. Transportation - Travel Time to Rt. 128 & Rt. 3
62. Transportation - Travel Time to Brockton, 5 min. zon
63. Transportation - Travel Time to Plymouth, 5 min. zon
64. Transportation - Distance to Projected Ltd. Acc. Highway, 1 km. zones
65. Transportation - Distance to Ltd. Acc. Highway Interchange, 1 km. zones
66. Environmental Nuisances - Predominant Type
67. Zoning
68. Residential Zoning - % Area in Cell
69. Commercial Zoning - % Area in Cell
70. Industrial Zoning - % Area in Cell
71. Watershed Number
72. Census Tract Number
73. Town Number
74. Sequence Number
75. UTM Cell Number - Easting (column)
76. UTM Cell Number - Northing (row)

Data Maps

Fig. B.2. Topography - Centroid Elevation
B.3. Topography - % Area, 0-3% Slope
B.4. Topography - % Area, 15%+ Slope
B.5. Landform - Predominant Type
B.6. Soil Type
B.7. Water - % Area, Wetlands
B.8. Water - Predominant Type
B.9. Forest - % Area, Deciduous
B.10. Forest - % Area, Coniferous
B.11. Forest - Predominant Density
B.12. Agriculture - % Area in Active Agriculture
B.13. Developed Land - % of Area
B.14. Residential - Predominant Density
B.15. Residential - Predominant Type
B.16. Residential - Predominant Maintenance Quality
B.17. Public & Semi-Public Land - Predominant Type
B.18. Recreation - Predominant Type
B.19. Transportation - Air and Rail, Major Type
B.20. Transportation - Road, Major Type
B.21. Transportation - Distance to Projected Limited Access Highway Network
B.22. Environmental Nuisance - Dominant Type
B.23. Zoning - Predominant Type

In the last three weeks each student attempted to implement the theories and concepts of natural systems and resource analysis developed previously. He was expected to develop the structure, logic and output of an analysis model of one aspect of "sector" of the developmental or natural systems which are interacting in the study area. These can be simply grouped as those sectors which effect the environment, such as new and existing development of industry, housing and transportation; or as those which represent the impact of development, such as flooding, water pollution and loss of wildlife.

Each student developed the analysis model of his choice, prepared the appropriate computer analysis program, obtained graphic output, and analyzed the output for the following assumed conditions:

1. A population increase in the study area of 300,000 persons over the next twenty years.

2. No unforeseen major technological changes during this period.

3. New development of the following types:

   a. Housing with associated commercial activities;
   b. Industrial development;
   c. Recreational and open-space facilities serving the larger metropolitan region (also growing in

the twenty year period), with a demand on the study area by 800,000 people.

d. Necessary transportation facilities for these, including roads, extensions of mass transportatio and a regional airport.

The analyses that resulted from this study can be evaluated at three levels. The theoretical ideas which underly the model and which are expressed in model diagrams (having a varying level of sophistication) are the first evaluation. The second is the ability of the student to translate his theoretical model into the FORTRAN programming language and produce an analysis map. The third level is the ability of the student to master the graphic tools, both computer and hand, which are available to him.

No attempt was made to formally interrelate the component models in this course. However, in the Spring 1970 semester, two groups will be developing these studies further; one will develop planning and design proposals for the region, and the other will design a simulation model to project and evaluate the region's future growth.

Figures B-24 to B-52 present a selection of the summary m from these subsystem models. In most cases several subanalyses were also made, but they are too numerous to reproduce here. The titles for each map will be easy to interpret when the following basic approaches are kept in mind:

a. Models 1-8 determine the locations which are suitable or attractive for various activities which effect the natural resources. In general, these models have component analyses of physical site conditions, relative accessibility and local community variables.

b. Models 9-18 attempt to determine the impacts of development on the natural resources. They cannot be simply described. Their intent is embodied in the title. The models illustrate a portion of the types of analyses that can be performed with such an information system.

c. When reading quantitative maps, one basic rule must be remembered: black is better or more, and white is worse or less. For qualitative maps, a specific symbol key is provided.

Suitability for Housing (High, Medium, Low Income)
B. Callaway, T. Adams, J. Kelleher

Fig. B.24. Suitability for High Income Housing
B.25. Suitability for Medium Income Housing
B.26. Suitability for Low Income Housing

Locational Costs for Industry
B. Thompson

Fig. B.27. Site Construction Costs for Industry
B.28. Access and Town Costs for Industry
B.29. Composite Cost Map for Industry

Suitability for Regional Commercial Centers
J. Olson

B.30. Suitability for Regional Commercial Centers

Suitability for Institutions - Hospitals and Community Colleges
K. Helphand, A. Boutilier

B.31. Suitability for Hospitals
B.32. Suitability for Community Colleges

Mass Transit - Suitability for Mass Transit Interchange
J. Braun

B.33. Suitability for Mass Transit Interchange

Suitability for a Regional Airport
J. Mega, K. Paolini

B.34. Suitability for a Regional Airport Based on Physical Factors
B.35. Suitability for a Regional Airport Based on Social Factors

Location of Commercial Recreation
D. Page

B.36. Suitability for Commercial Recreation

Suitability for Public Recreation Development
S. Handler, J. Coffield

B.37. Attractiveness for Land Trails
B.38. Attractiveness for Camping Sites
B.39. Attractiveness for Water Trails
B.40. Composite of Attractiveness for Inland Outdoor Recreation Activities
B.41. Suitability for a State Park

Conservation - General Considerations
W. Williams

B.42. Attractiveness for Conservation

Conservation - Forests and Open Lands
I. Maass

B.43. Attractiveness of Forests for Conservation

Prediction of Location of Wildlife Habitats
S. Calhoun

B.44. Potential Wildlife Habitat

Ecosystem Stability Models
D. Orwig

B.45. Ecological Stability
B.46. Ecological Stability

Prediction of Wetland Loss
L. Urban

B.47. Pressure on Wetlands for Filling

Prediction of Water Pollution by Septic Tanks
V. Pratt

B.48. Vulnerability to Septic Tank Pollution

Prediction of Storm Water Run-Off
B. Tsuchida

B.49. Relative Storm Water Run-Off in a Heavy Rain

Prediction of the Impact of Change on Watersheds
P. Bochenek

B.50. Potential Damage to Watershed by Change

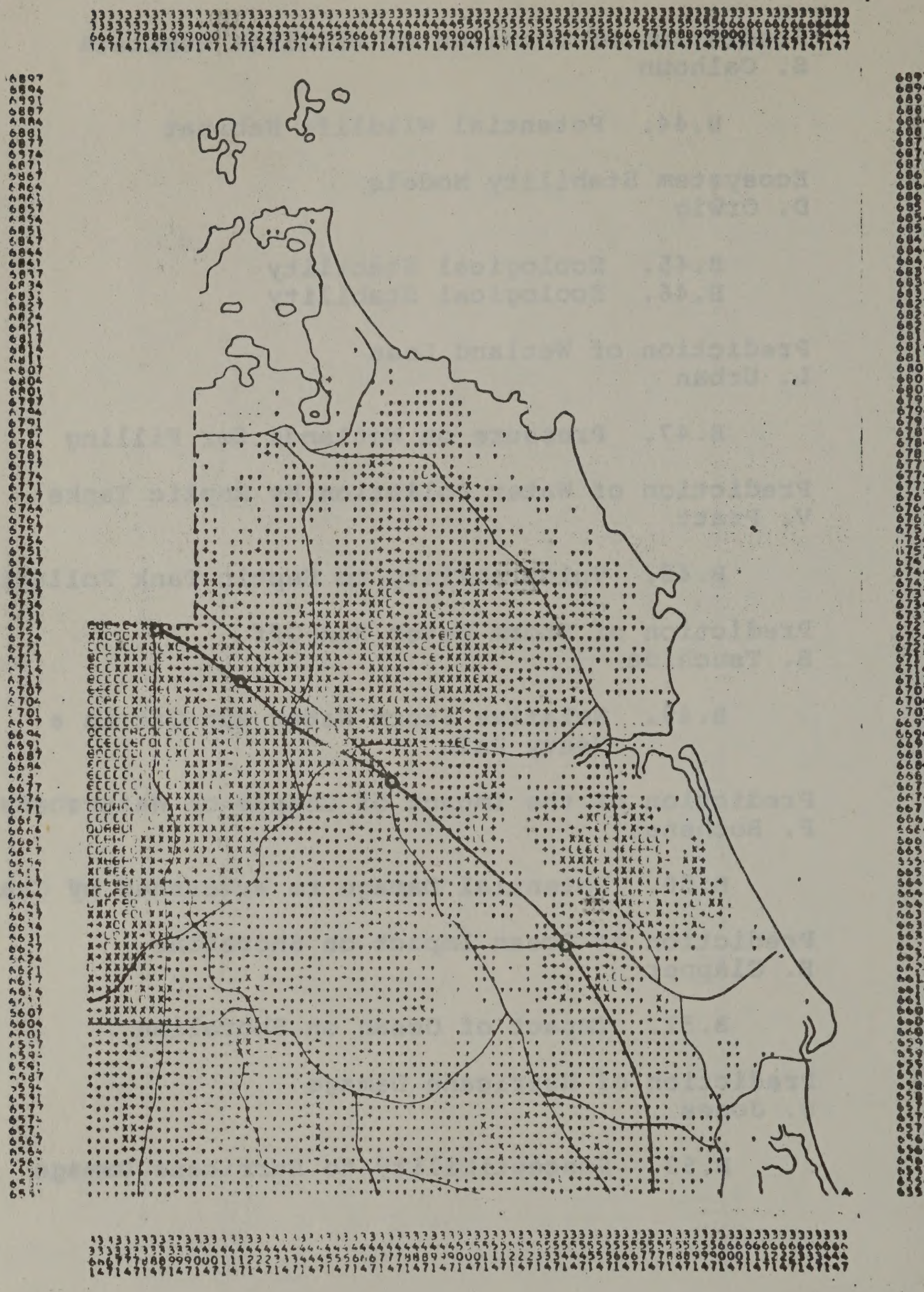
Prediction of Ocean Impact on Shoreline
R. Clapper

B.51. Impact of Ocean on Shoreline

Prediction of Hurricane Damage
S. Jones

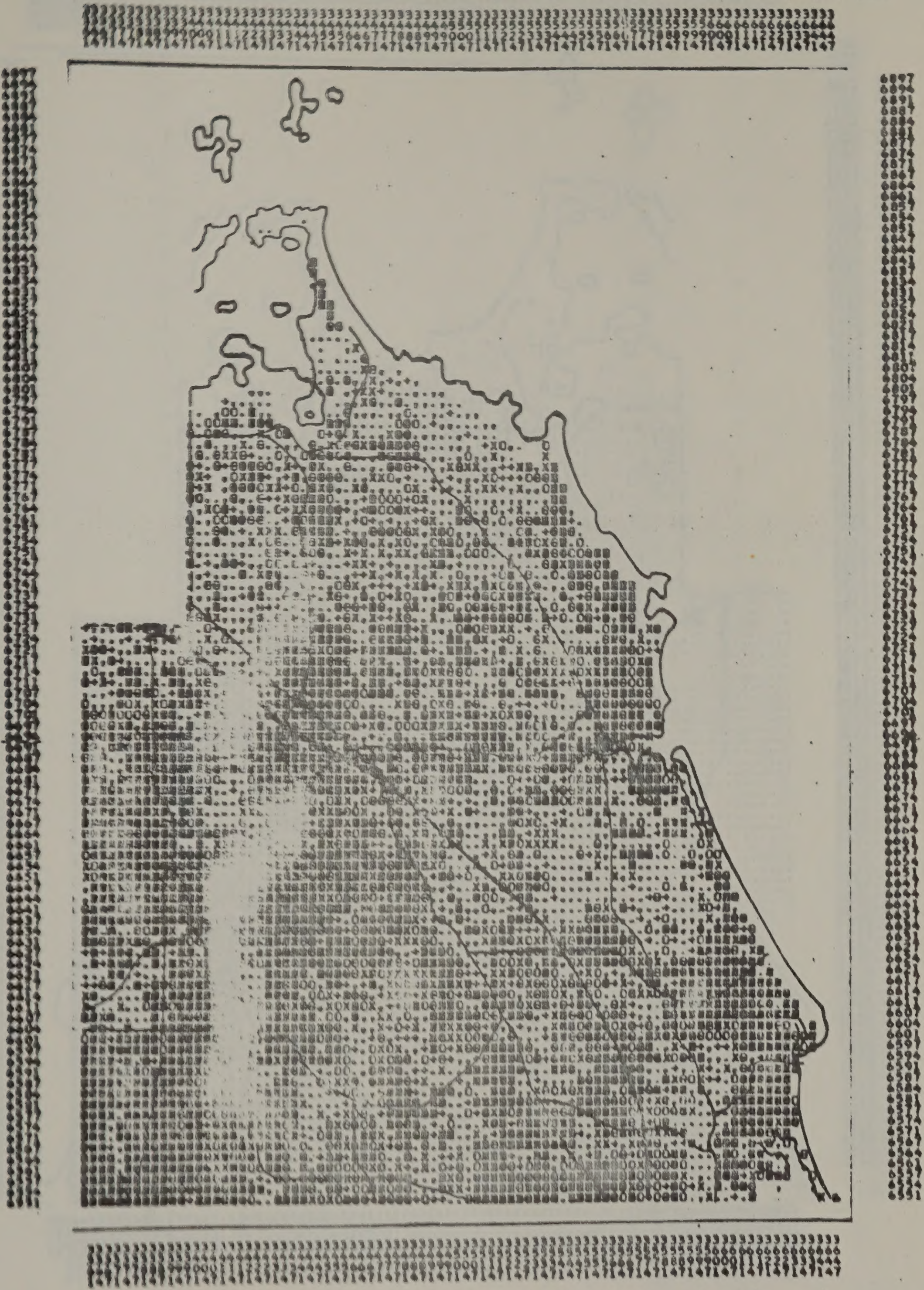
B.52. Susceptibility to Hurricane Damage

FIG. B.2 BOSTON REGION : SOUTHEAST SECTOR
TOPOGRAPHY - CENTROID ELEVATION



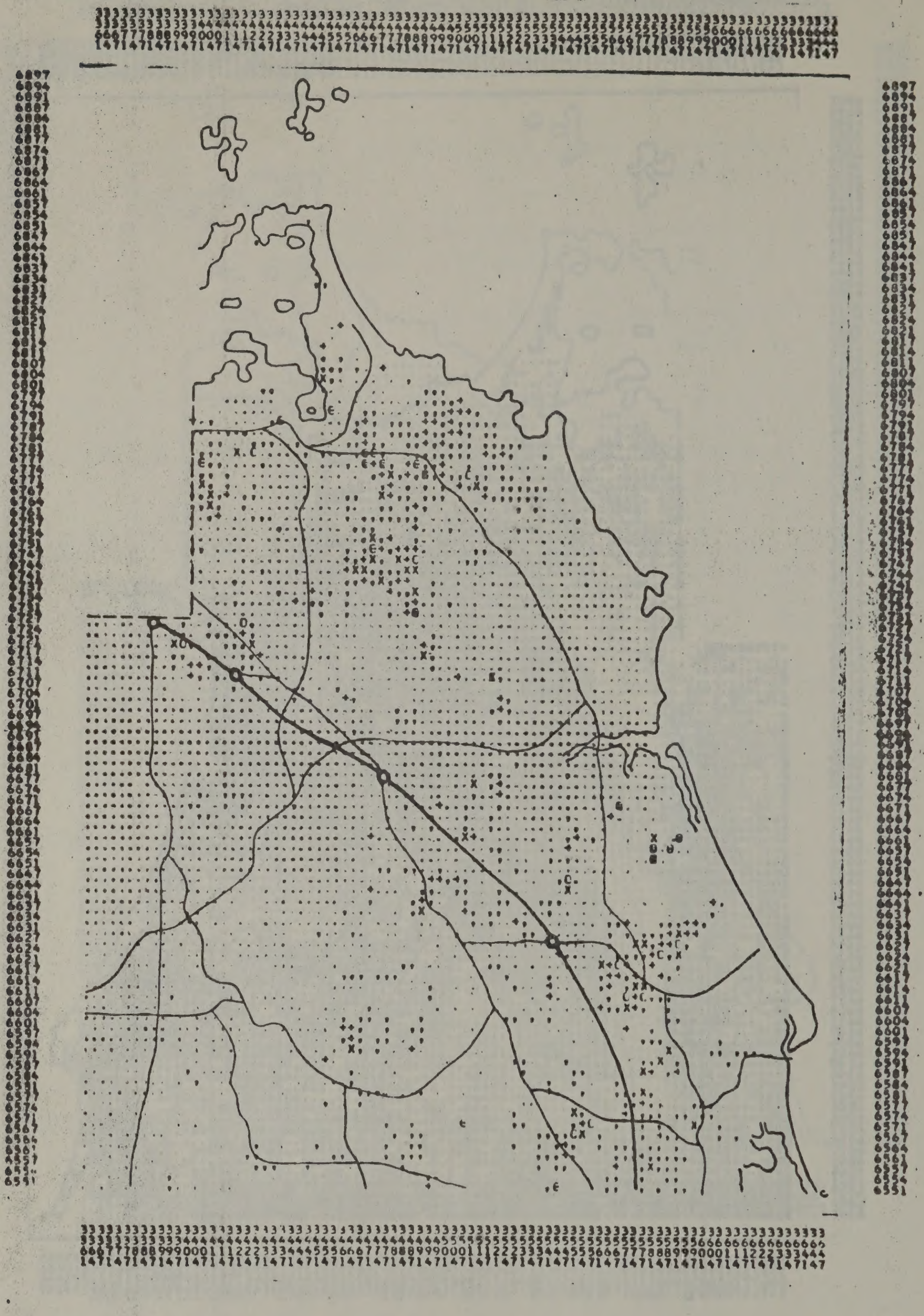
Elevations range from sea level to 300'

FIG. B.3 BOSTON REGION : SOUTHEAST SECTOR
TOPOGRAPHY - % AREA 0-3% SLOPE



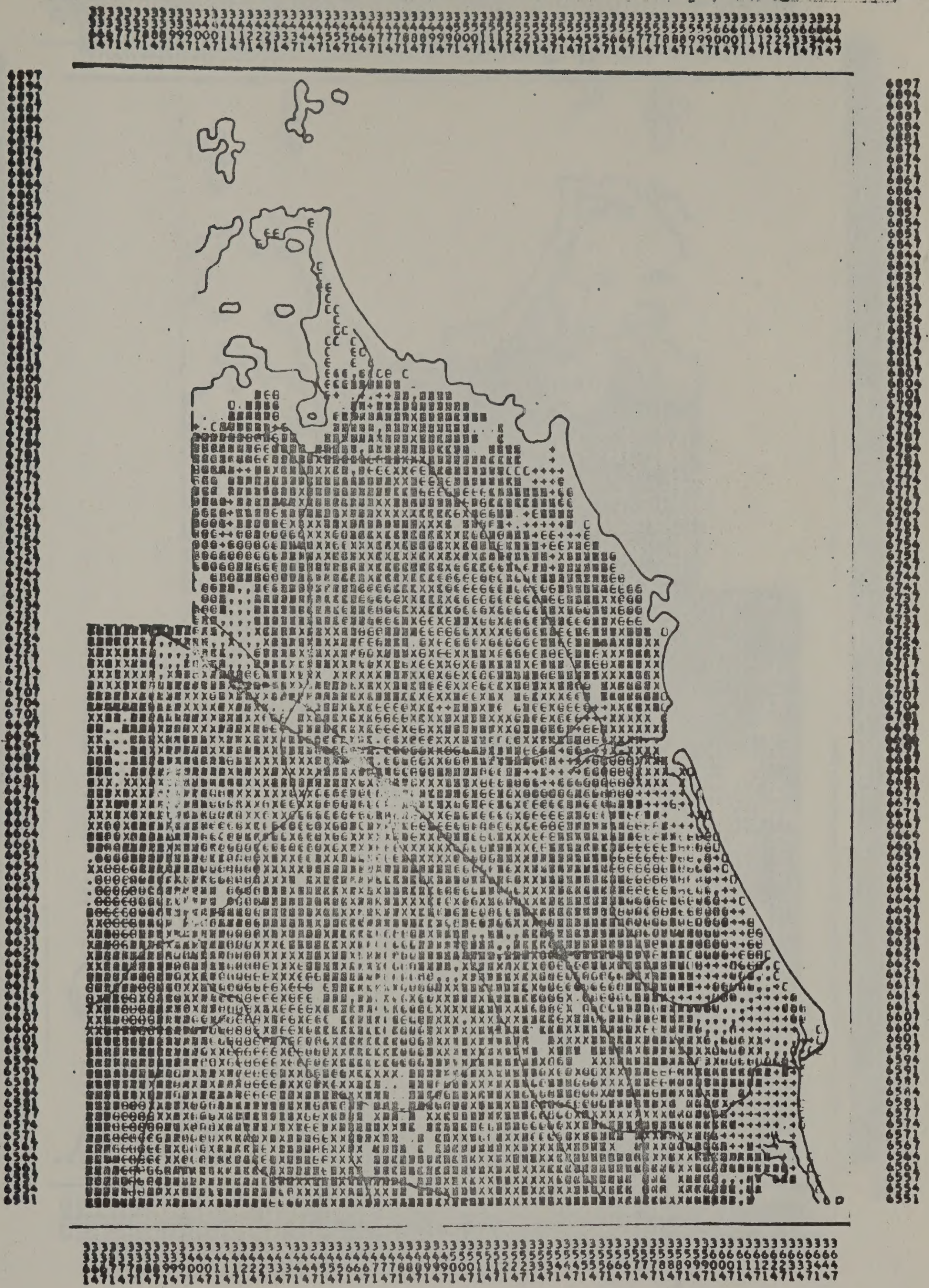
. 0 = 0-9%
to
■ 9 = 90-100%

FIG. B.4 BOSTON REGION : SOUTHEAST SECTOR
TOPOGRAPHY - % AREA 15% + SLOPE



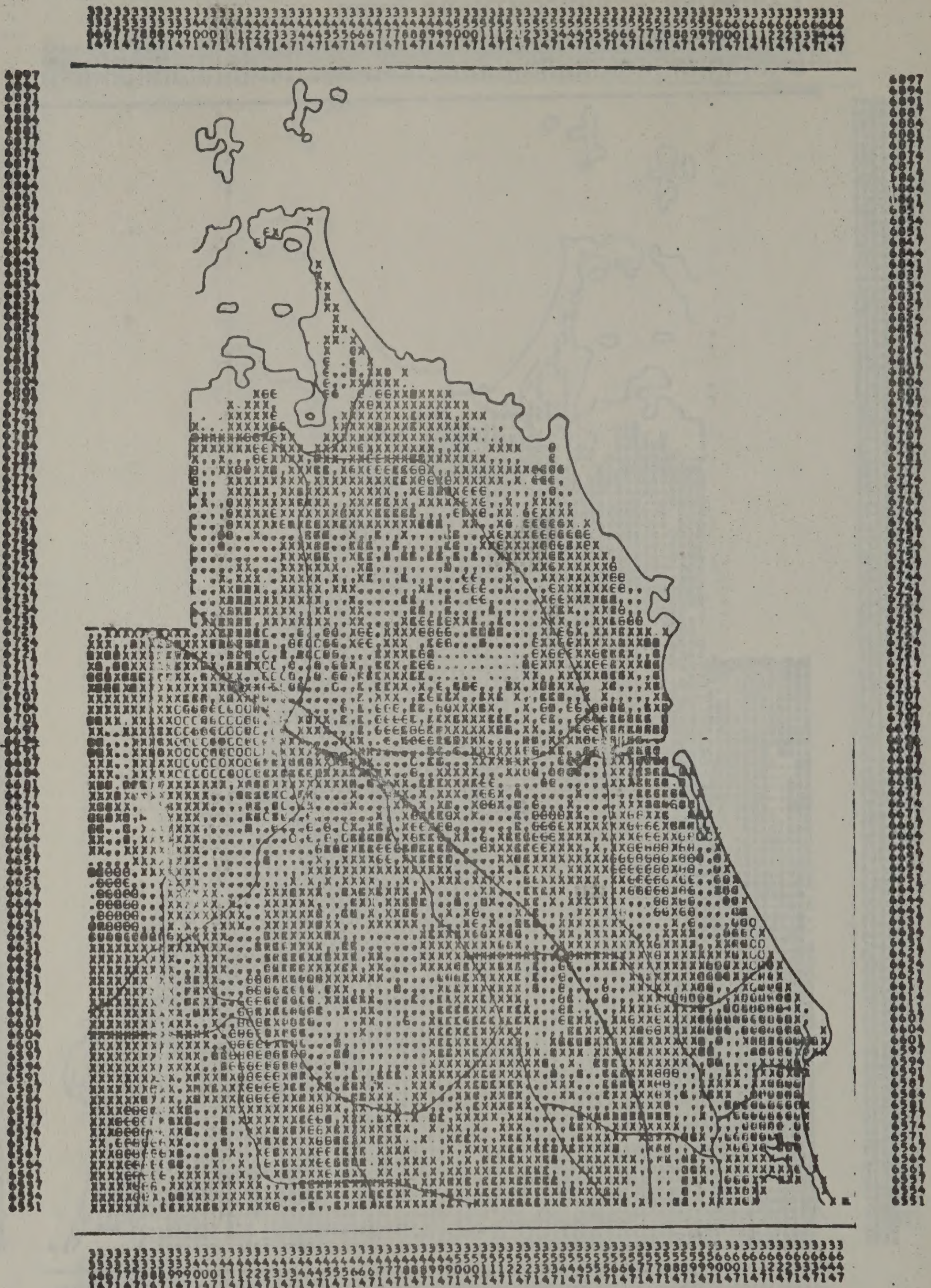
. 0 = 0-9%
to
■ 9 = 90-100%

FIG. B.5 BOSTON REGION : SOUTHEAST SECTOR
LANDFORM - PREDOMINANT TYPE



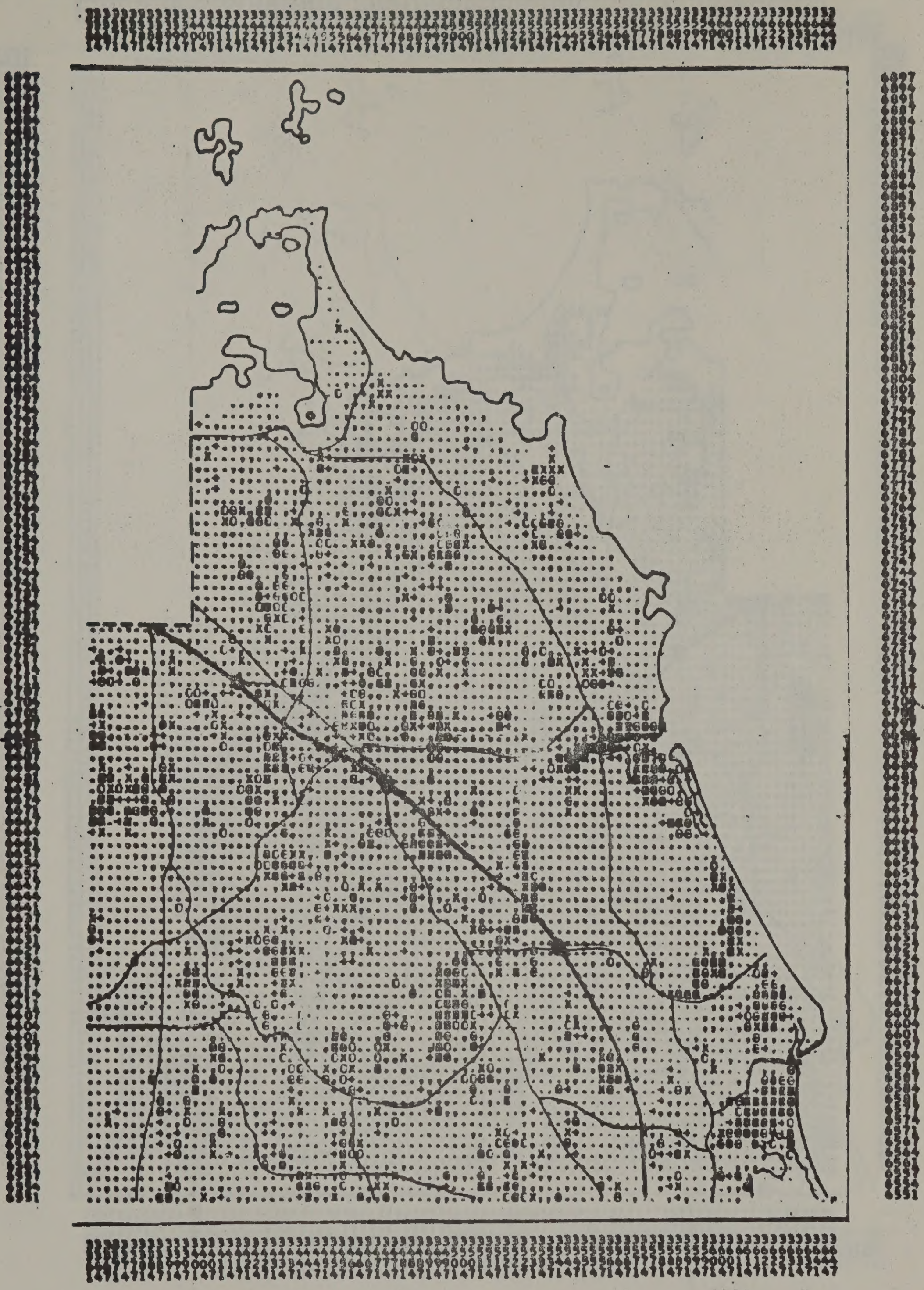
. 0 = Water
, 1 = Rock
, 2 = Flood Plain
+ 3 = Coastal Wetlands
X 4 = Organic Deposit
O 5 = Beach Ridges
Θ 6 = Drumlins
● 7 = Till
⊠ 8 = Esker/Kame
■ 9 = Outwash

FIG. B.6 BOSTON REGION : SOUTHEAST SECTOR
SOIL TYPE



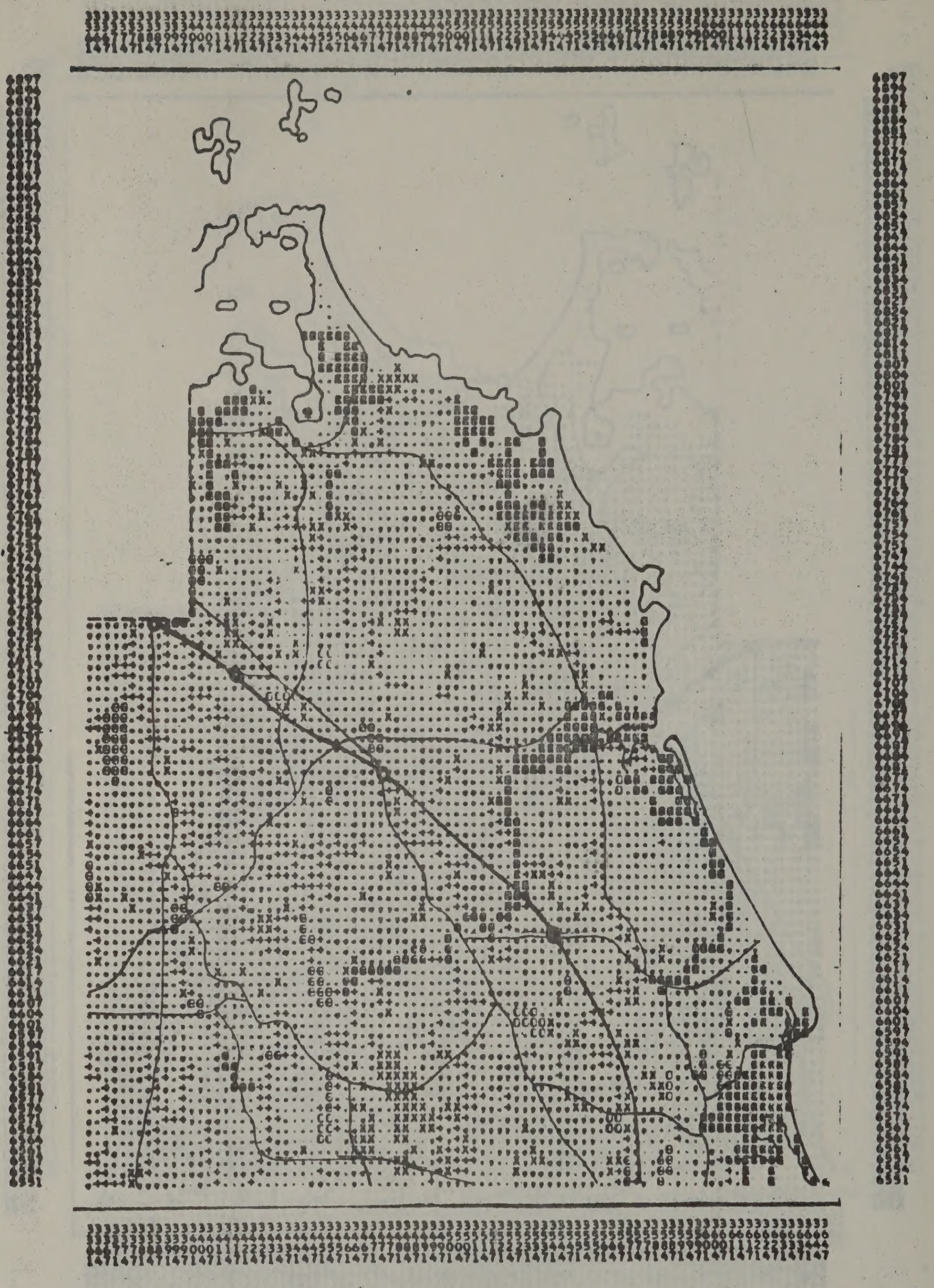
. 0 = Water
, 1 = Gravel - Coarse
, 2 = Gravel - Fines
X 4 = Sand = Coarse
O 5 = Sand - Fines
θ 6 = Silts and Clays liq 50
● 7 = Silts and Clays liq 50
⊠ 8 = Peat
■ 9 = None

FIG. B.7 BOSTON REGION : SOUTHEAST SECTOR
WATER - % AREA WETLANDS



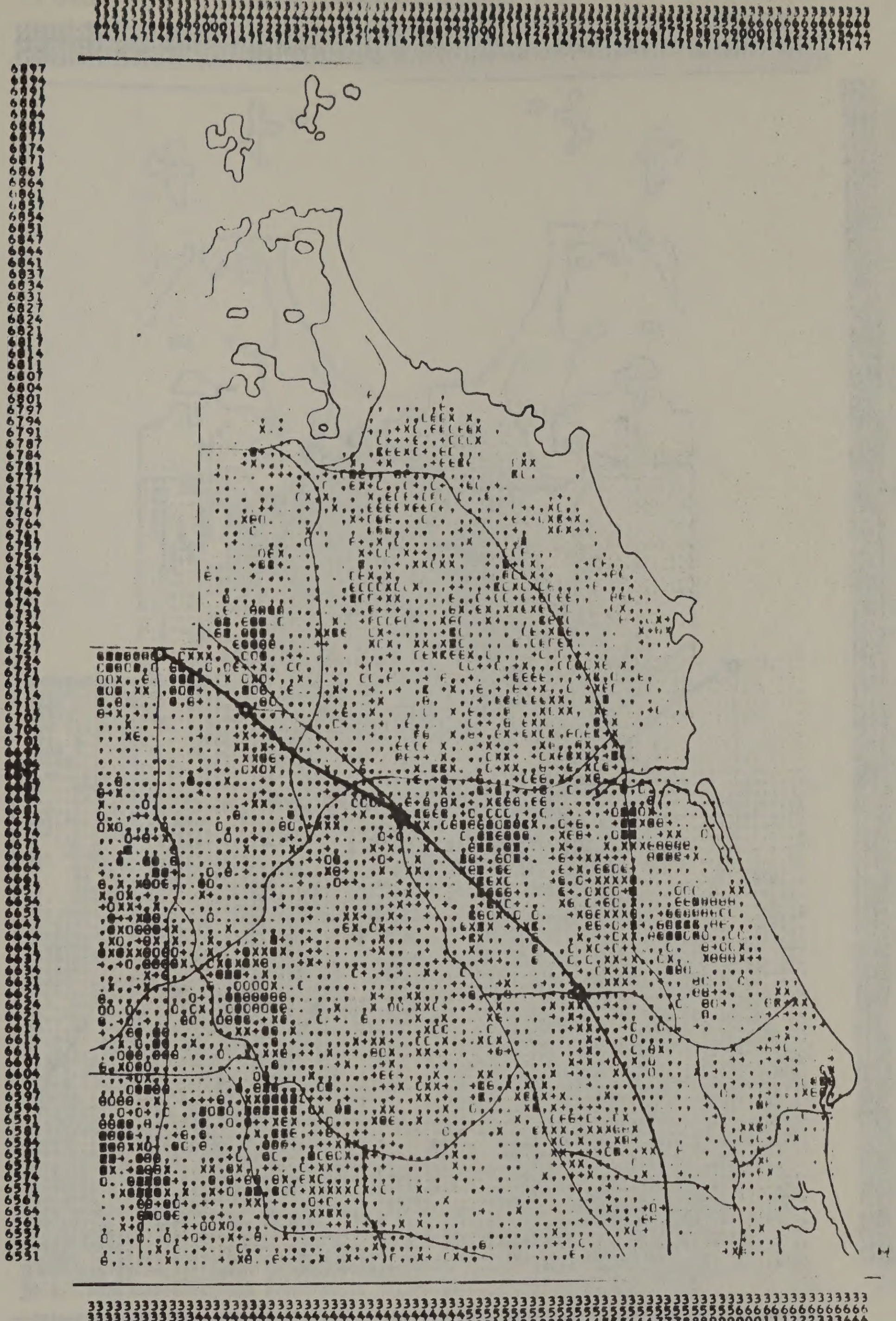
. 0 = 0-9%
to
■ 9 = 90-100%

FIG. B.8 BOSTON REGION : SOUTHEAST SECTOR
WATER - PREDOMINANT TYPE



. 0 = None
, 1 = Swales
, 2 = First Order Streams
+ 3 = Other Streams
X 4 = Ponds (less than 10 acres)
O 5 = Reservoirs
Θ 6 = Lakes
● 7 = Rivers
▨ 8 = Estuary
■ 9 = Ocean

FIG. B.9 BOSTON REGION : SOUTHEAST SECTOR
FOREST - % AREA DECIDUOUS

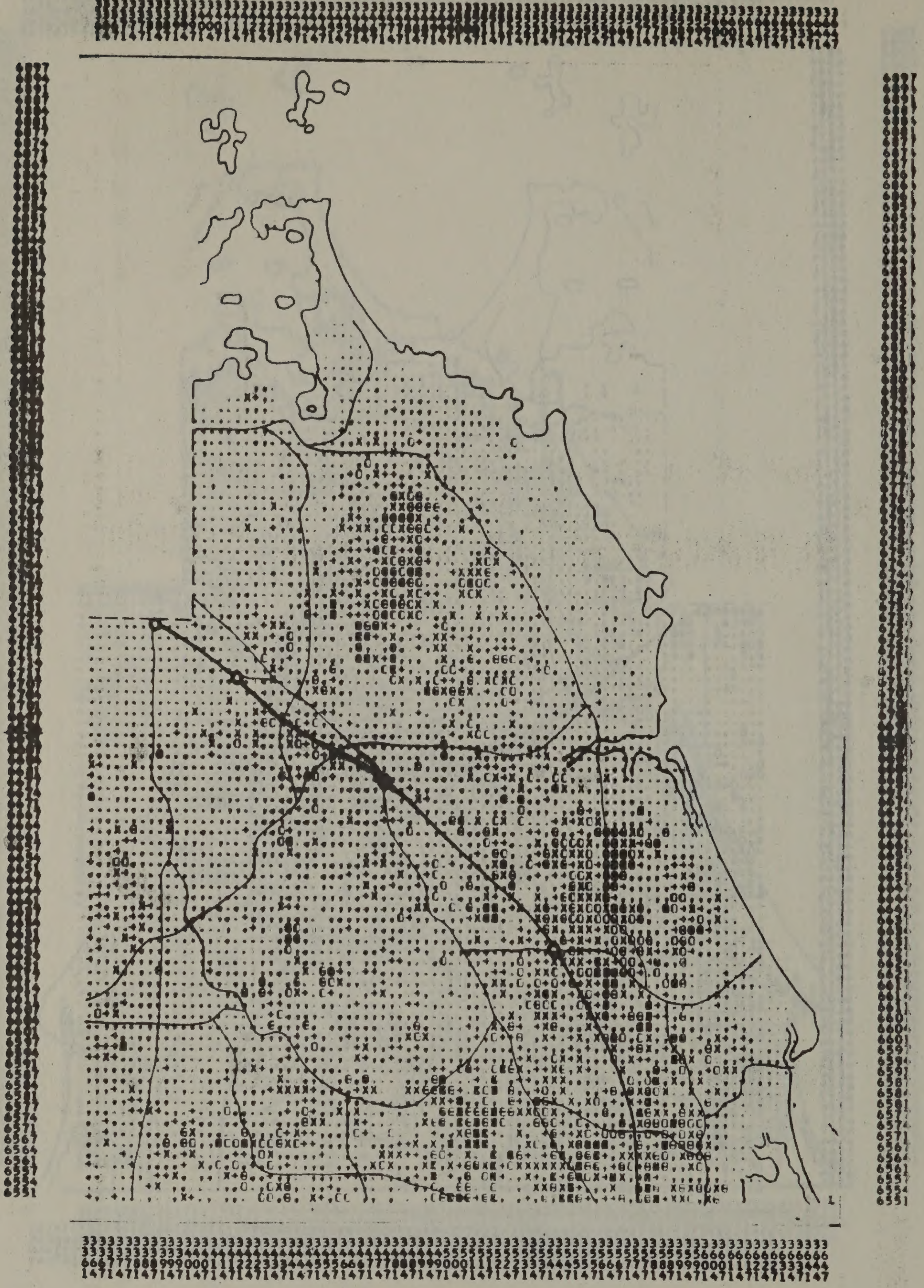


. 0 = 0-9%

to

■ 9 = 90-100%

FIG. B.10 BOSTON REGION : SOUTHEAST SECTOR
FOREST - % AREA CONIFEROUS

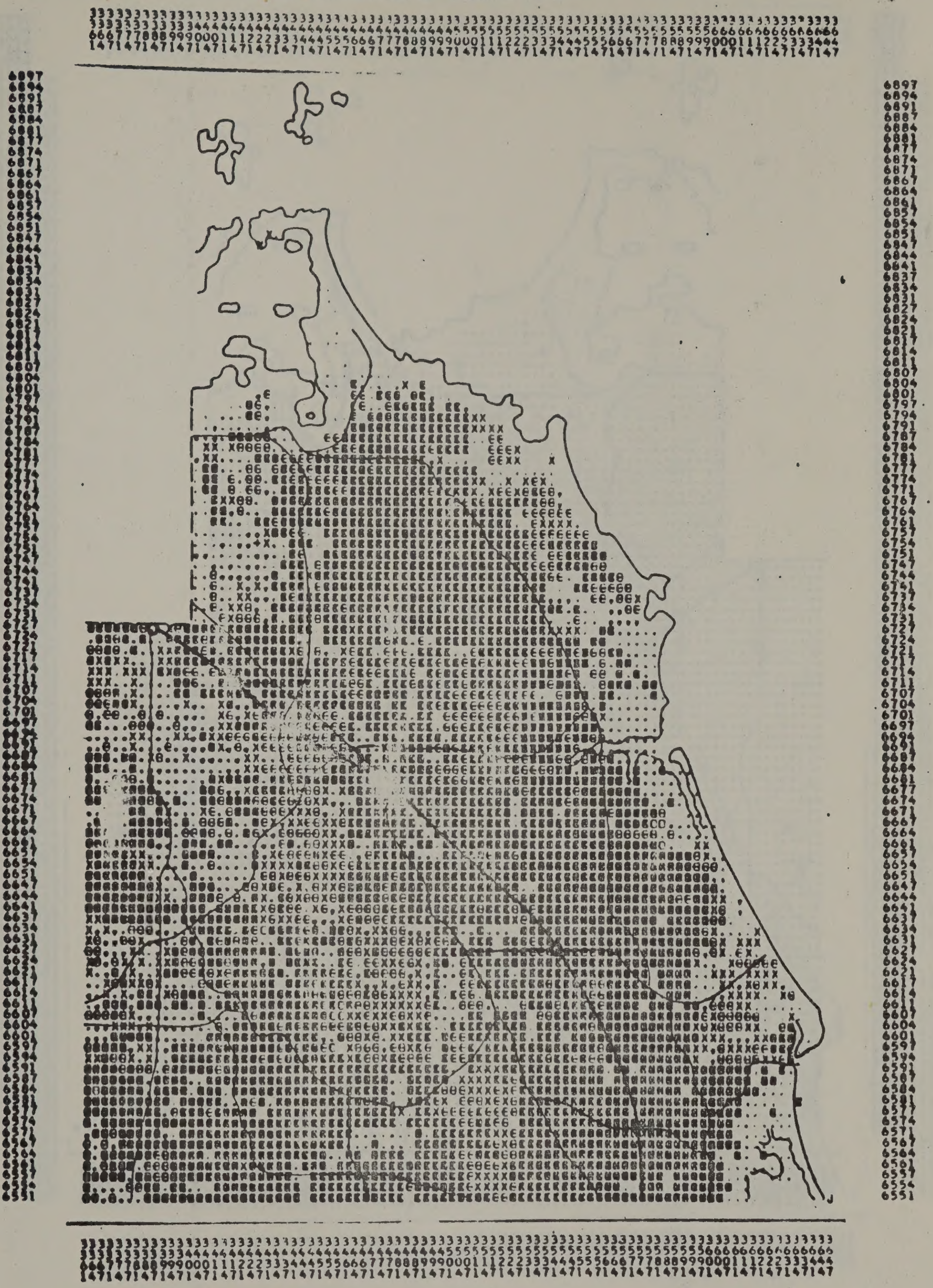


. 0 = 0-9%

to

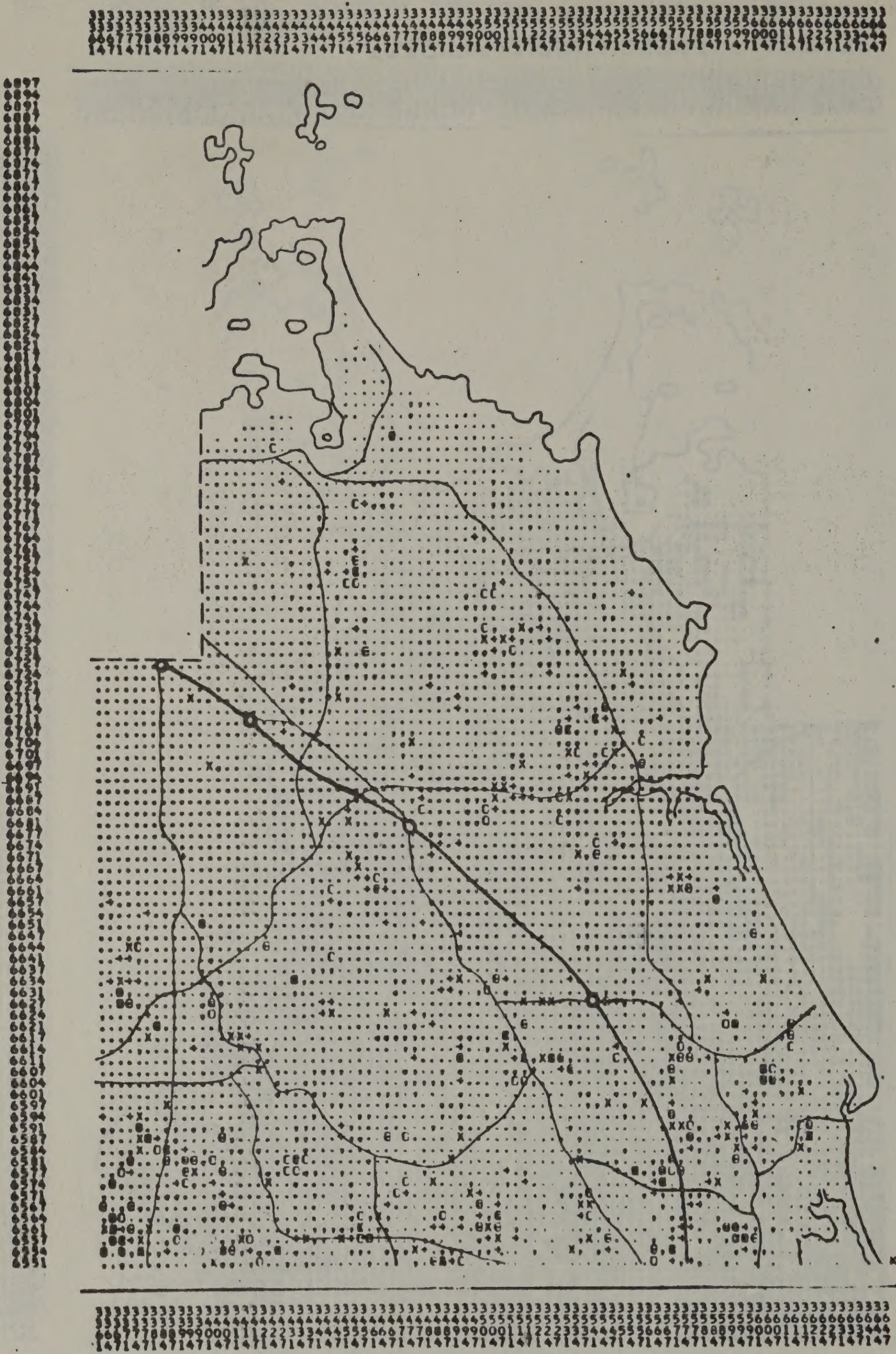
■ 9 = 90-100%

FIG. B.11 BOSTON REGION : SOUTHEAST SECTOR
FOREST - PREDOMINANT DENSITY



. 0 = None
, 2 = 30% Crown Coverage
X 4 = 31-50% Crown Coverage
θ 6 = 51-80% Crown Coverage
▨ 8 = 81-100% Crown Coverage

FIG. B.12 BOSTON REGION : SOUTHEAST SECTOR
AGRICULTURE - % AREA IN ACTIVE AGRICULTURE

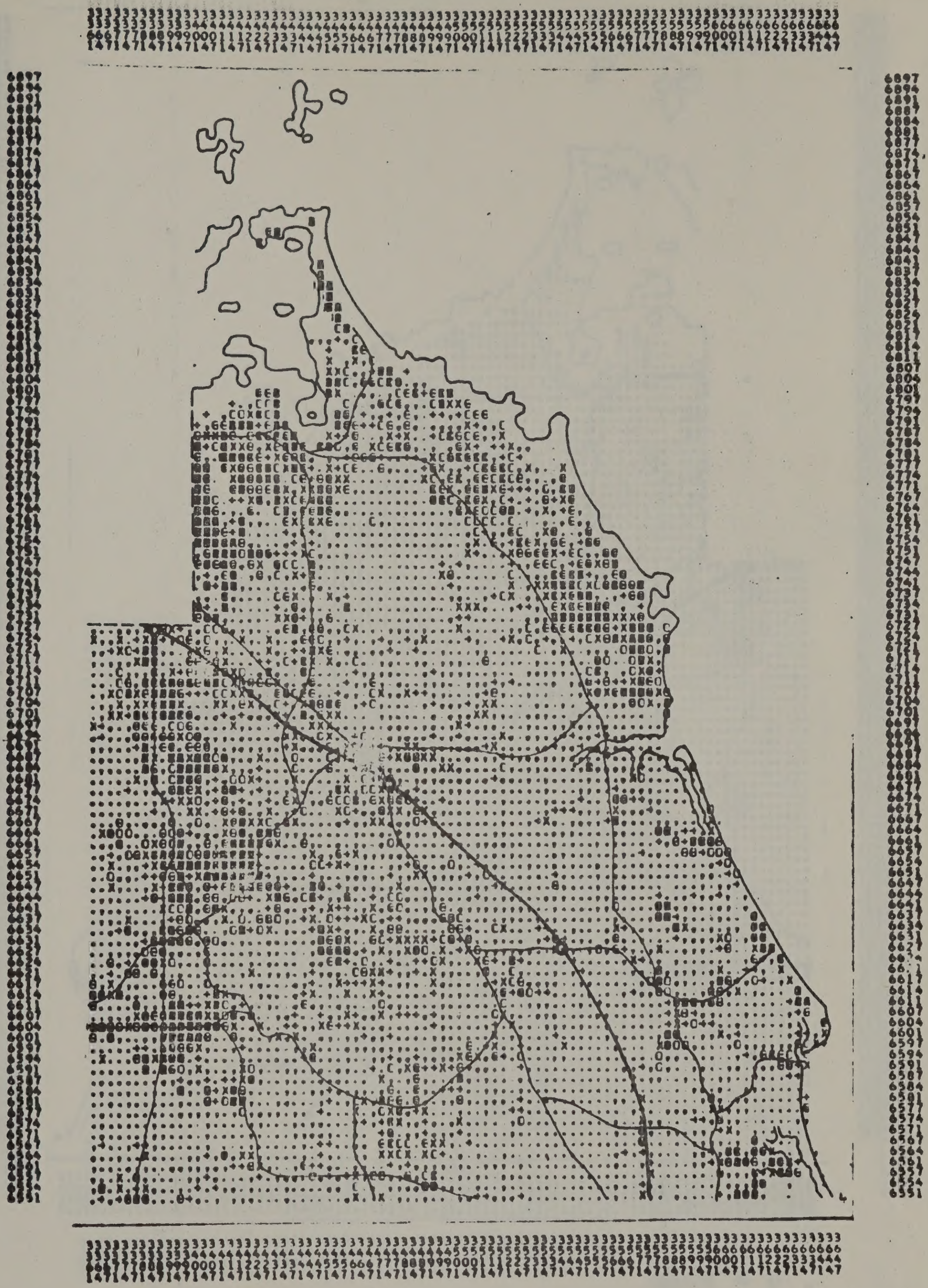


. 0 = 0-9%

to

■ 9 = 90-100%

FIG. B.13 BOSTON REGION : SOUTHEAST SECTOR
DEVELOPED LAND - % OF AREA

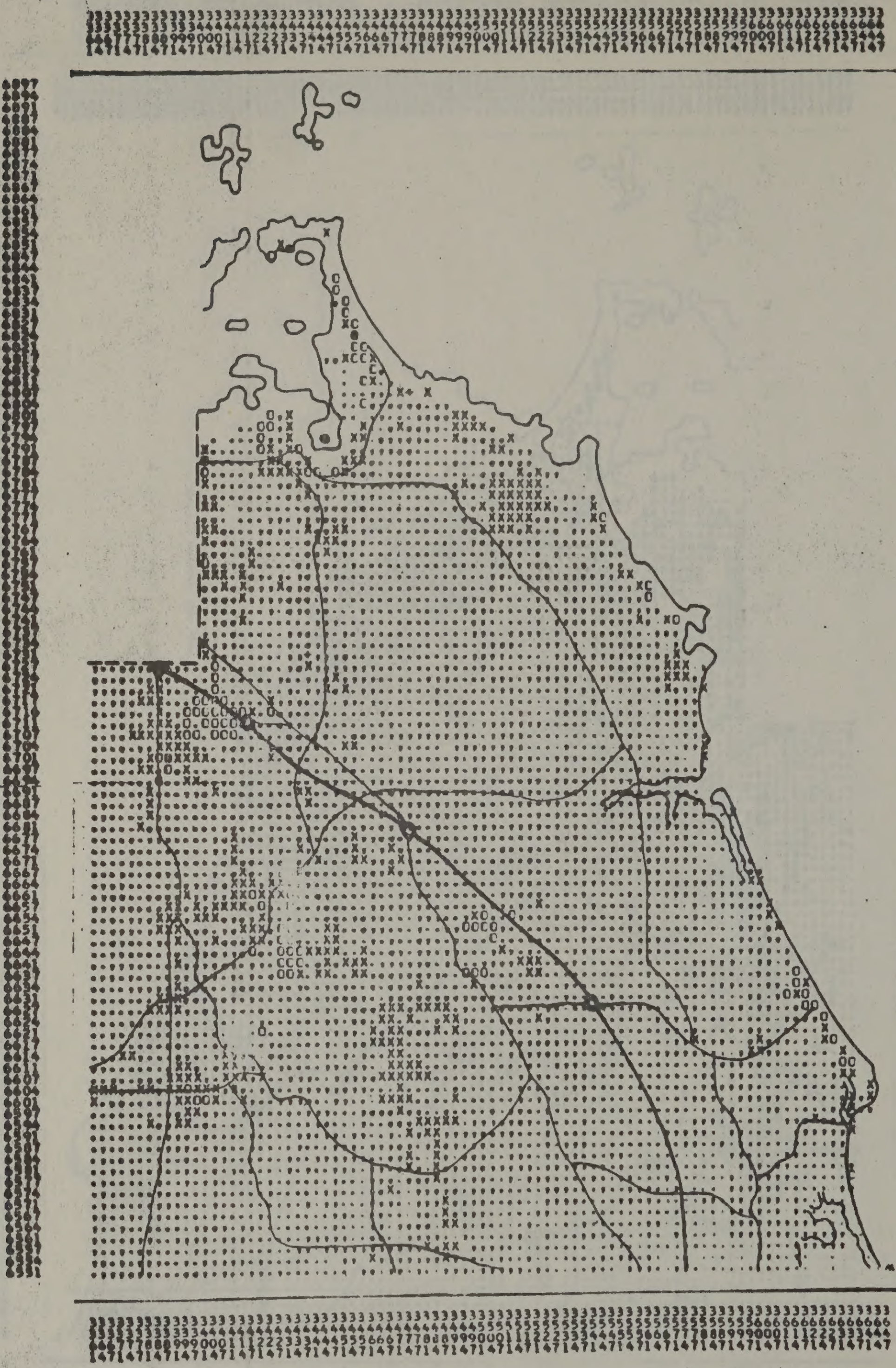


. 0 = 0-9%

to

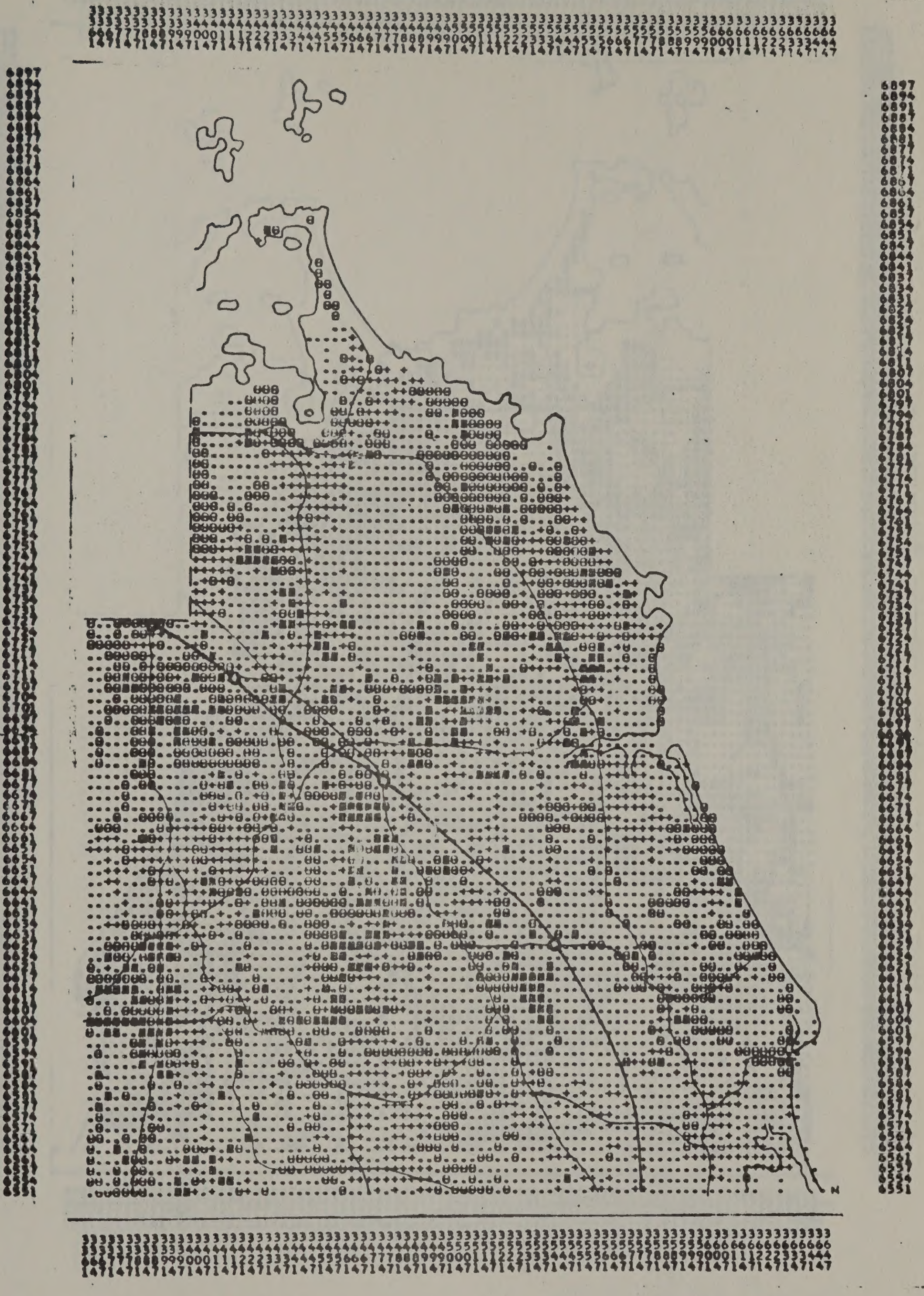
■ 9 = 90-100%

FIG. B.14 BOSTON REGION : SOUTHEAST SECTOR
RESIDENTIAL - PREDOMINANT DENSITY



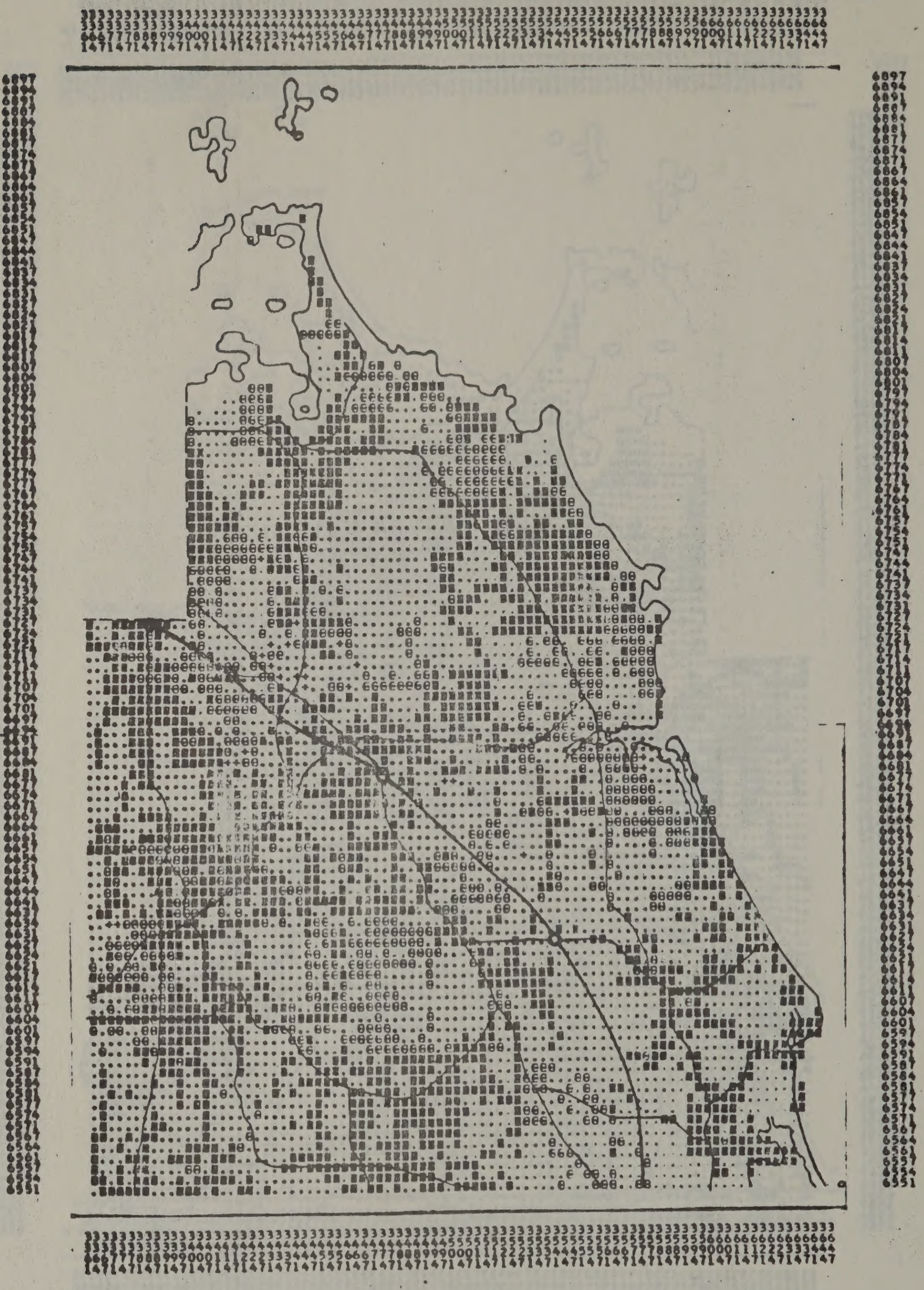
. 0 = None
, 1 = 0-12 Units (2 acre zoning)
, 2 = 13-25 Units (1 acre zoning)
X 4 = 26-60 Units (20,000 sq. ft. zoning)
O 5 = 61-200 Units (6,000 sq. ft. zoning)
⊖ 7 = 201-500 Units
■ 9 = 500 or More Units

FIG. B.15 BOSTON REGION : SOUTHEAST SECTOR
RESIDENTIAL - PREDOMINANT AGE OF DEVELOPMENT



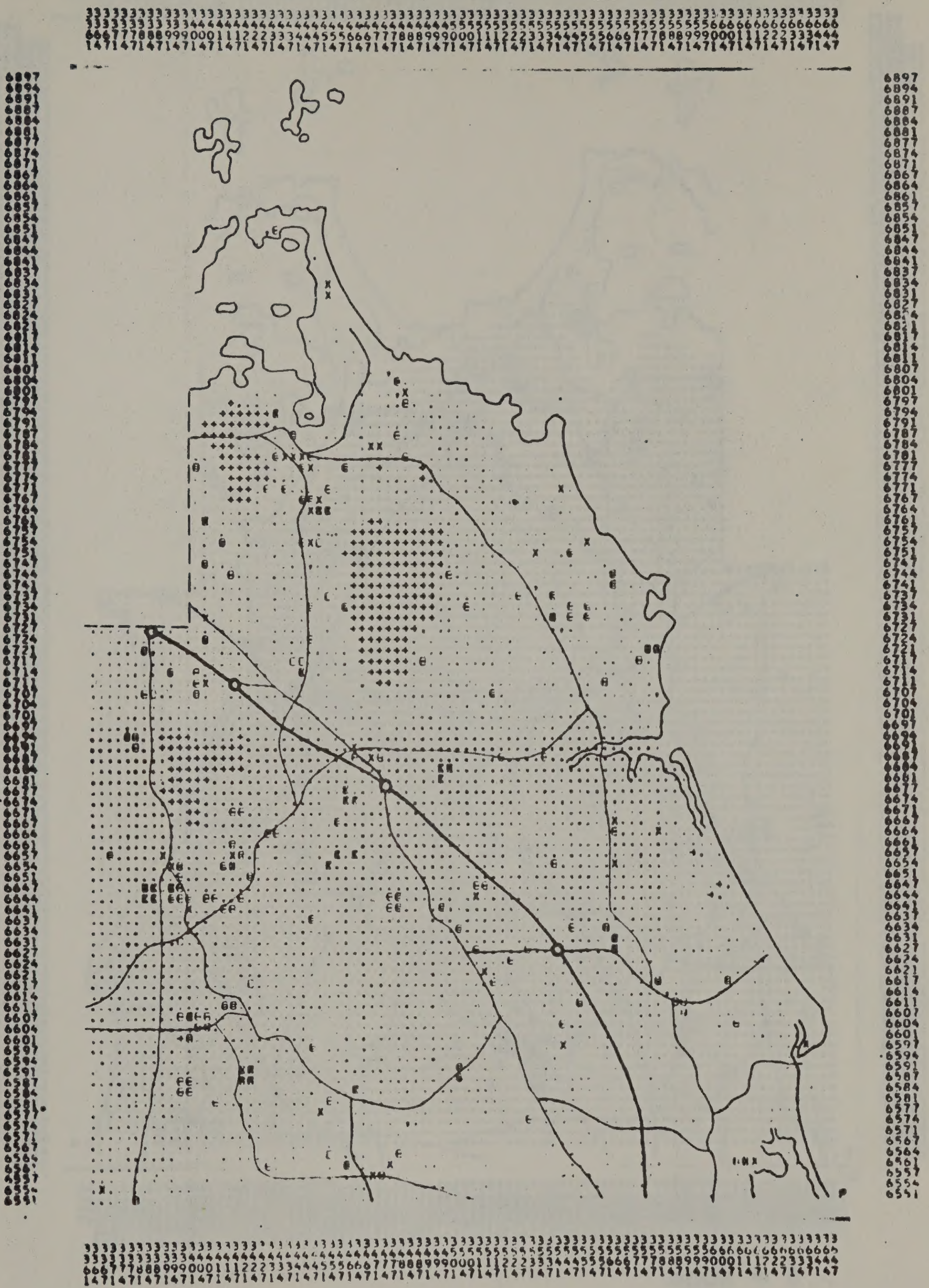
. 0 = None
+ 3 = Before 1940
ϴ 6 = 1940-1960
■ 9 = Since 1960

FIG. B.16 BOSTON REGION : SOUTHEAST SECTOR
RESIDENTIAL - PREDOMINANT MAINTENANCE QUALITY



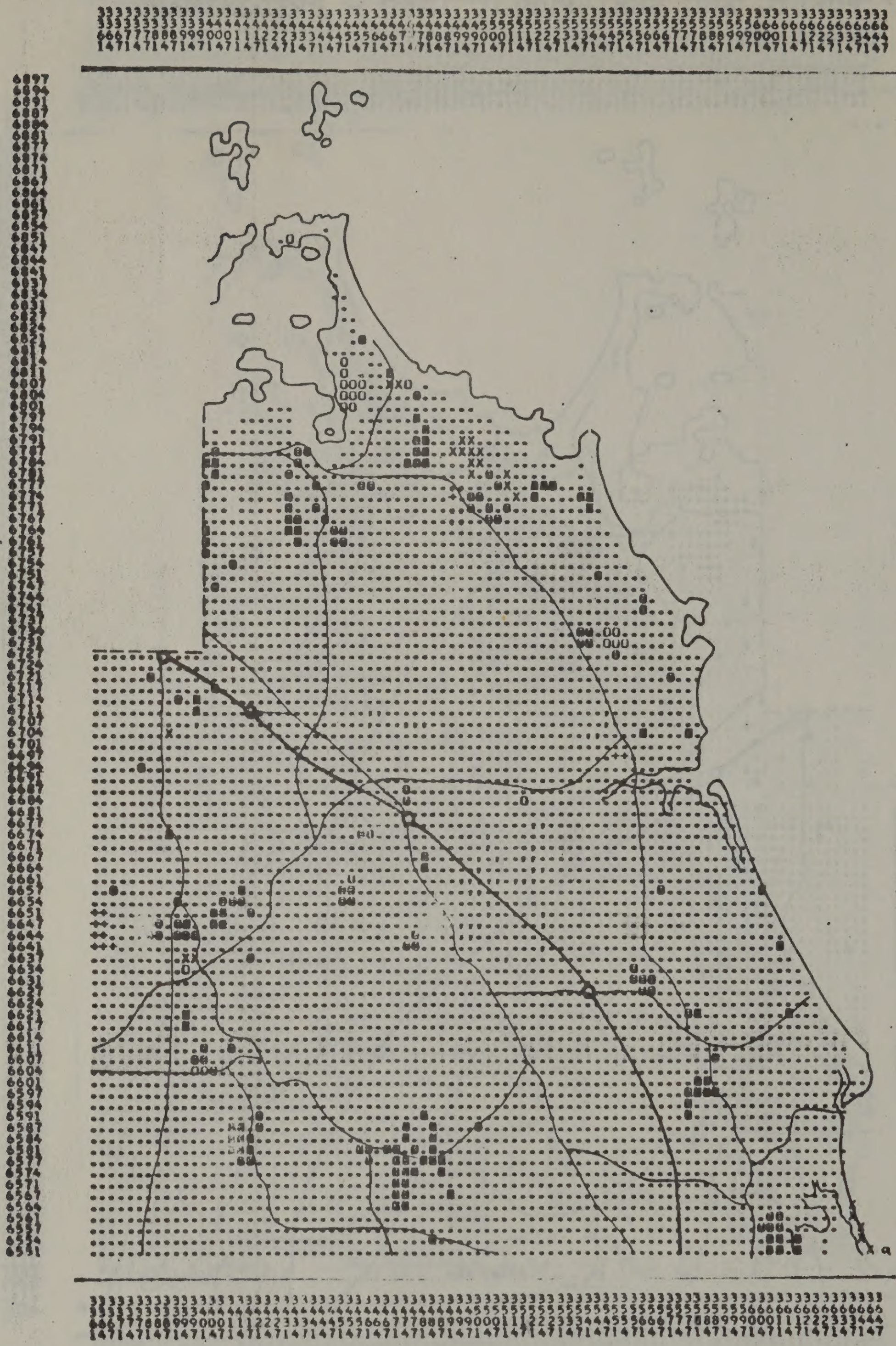
. 0 = None
+ 3 = Not Maintained
Θ 6 = Partial Maintenance
■ 9 = Maintained

FIG. B.17 BOSTON REGION : SOUTHEAST SECTOR
PUBLIC AND SEMI-PUBLIC LAND - PREDOMINANT TYPE



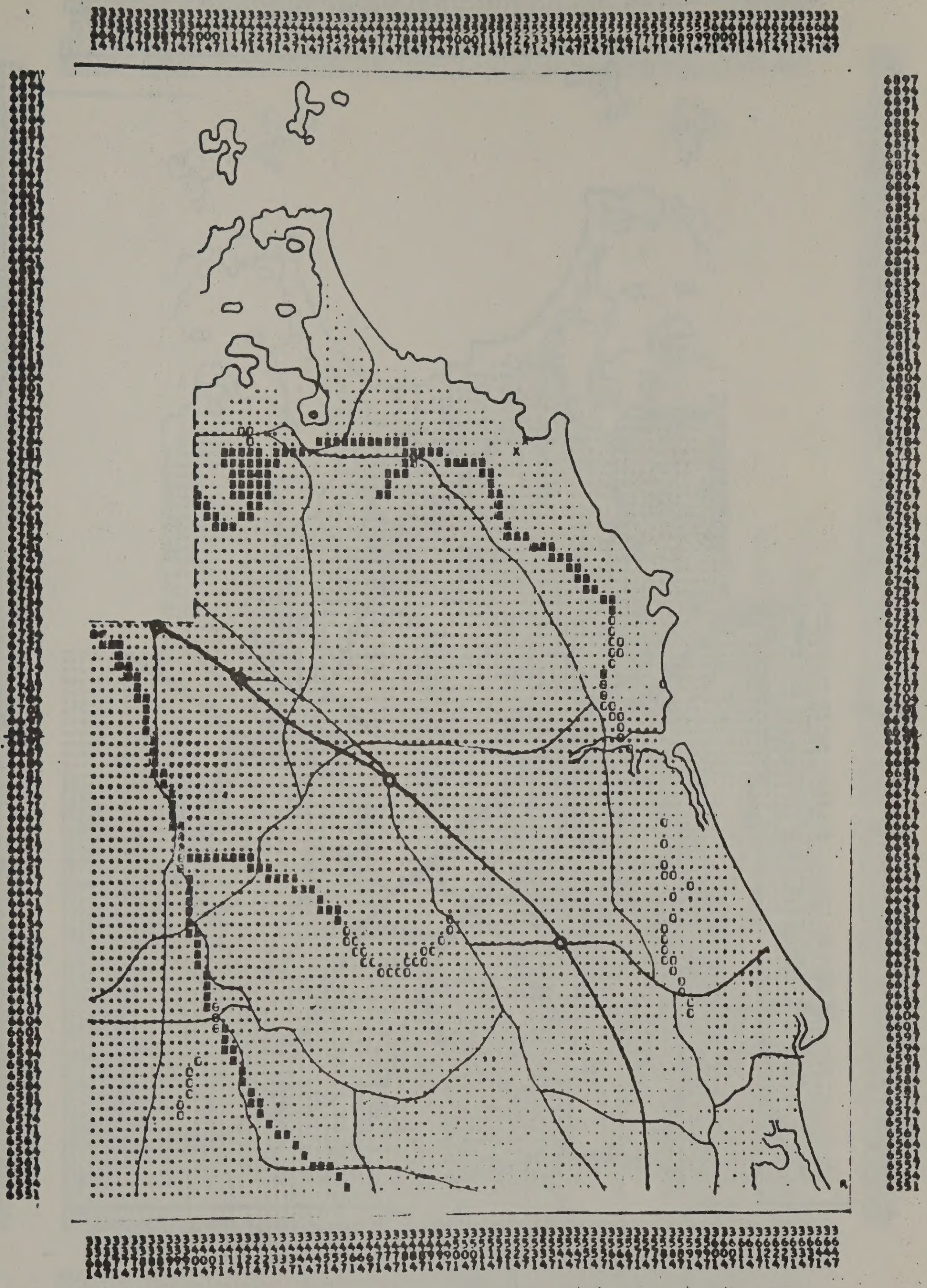
. 0 = None
, 1 = Public Administrative Buildings
, 2 = Correctional Institutions
+ 3 = Military Establishments
X 4 = Religious Establishments
O 5 = Health Establishments
θ 6 = Cemetaries
⊖ 7 = Education - Elementary and Junior High Schools
⊠ 8 = Education - High Schools
■ 9 = Education - Colleges and Universities

FIG. B.18 BOSTON REGION : SOUTHEAST SECTOR
RECREATION - PREDOMINANT TYPE



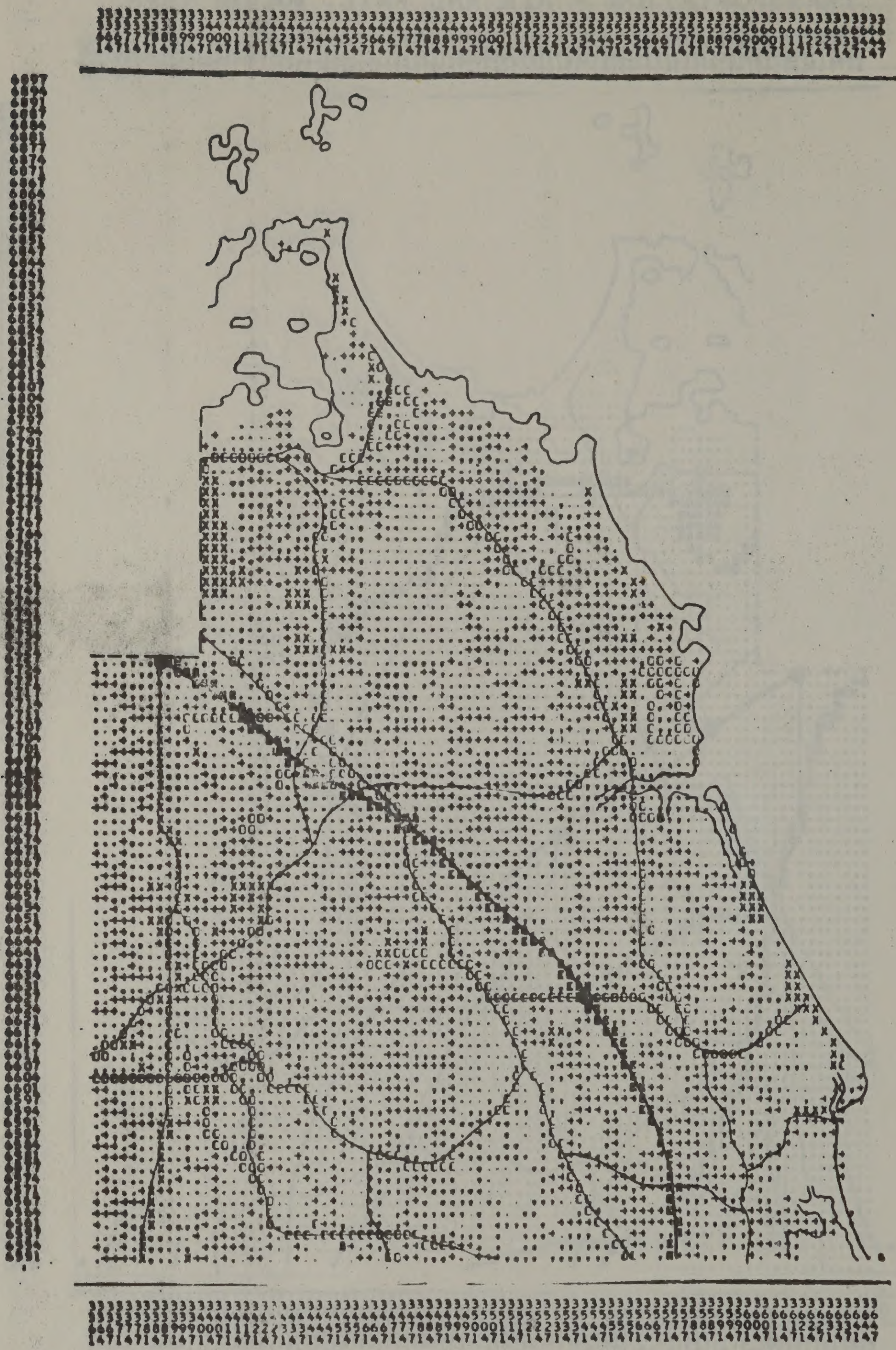
. 0 = None
, 1 = Wilderness
, 2 = Conservation
+ 3 = State and National Parks
X 4 = County and Local Parks
O 5 = Community Parks
θ 6 = Botanical and Zoological Parks
⊖ 7 = Playing Fields
⊠ 8 = Activity Facility
■ 9 = Commercial Facility

FIG. B.19 BOSTON REGION : SOUTHEAST SECTOR
TRANSPORTATION - AIR AND RAIL, MAJOR TYPE



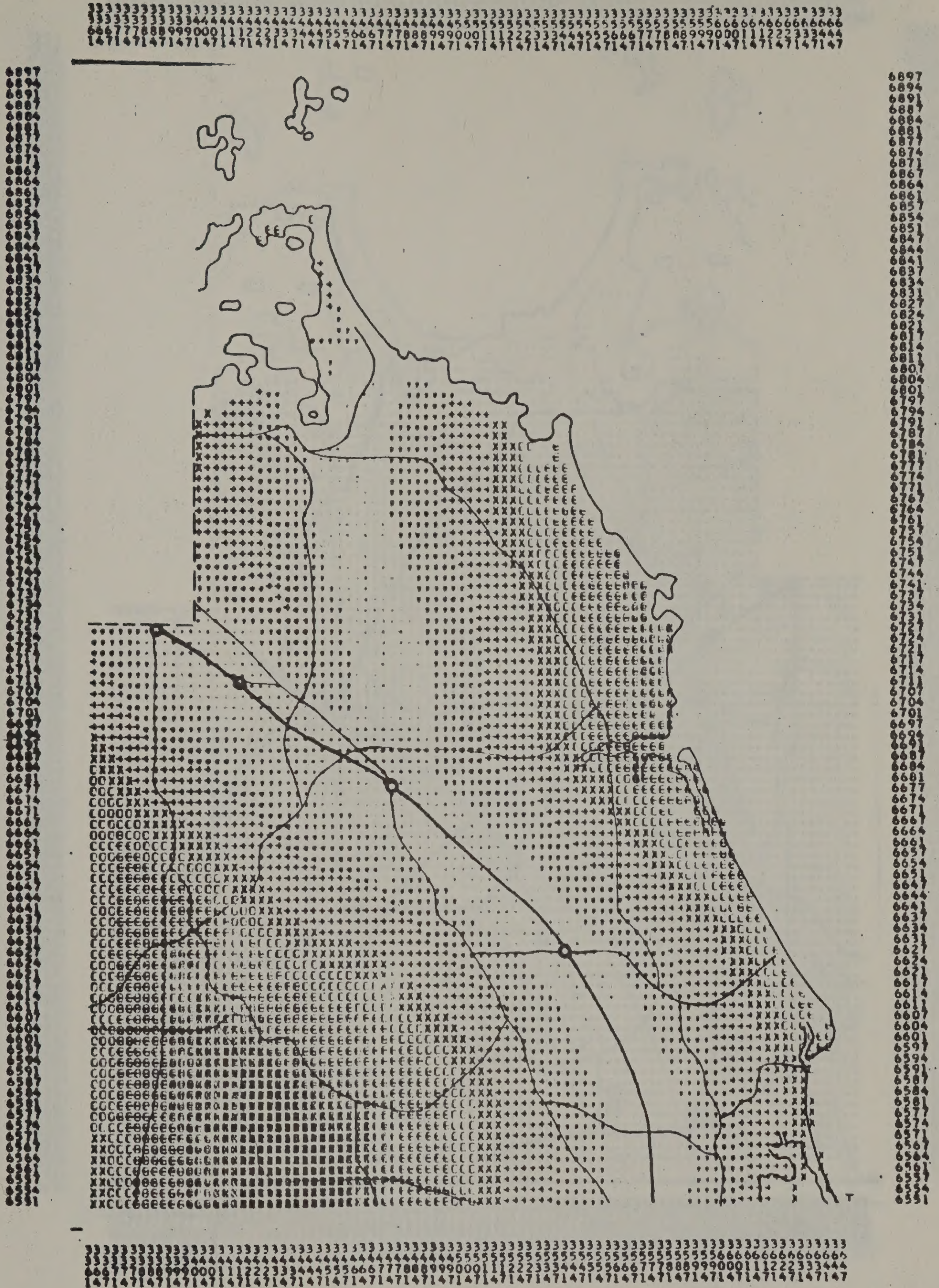
. 0 = None
, 1 = Turf Airfield
, 2 = Paved Airfield
+ 3 = Paved Airfield, high volume
X 4 = Light Houses
O 5 = Abandoned Rail Bed
Θ 6 = Railway Freight Yards
⊠ 8 = Mass Transit
■ 9 = Active Railway Line

FIG. B.20 BOSTON REGION : SOUTHEAST SECTOR
TRANSPORTATION - ROAD, MAJOR TYPE



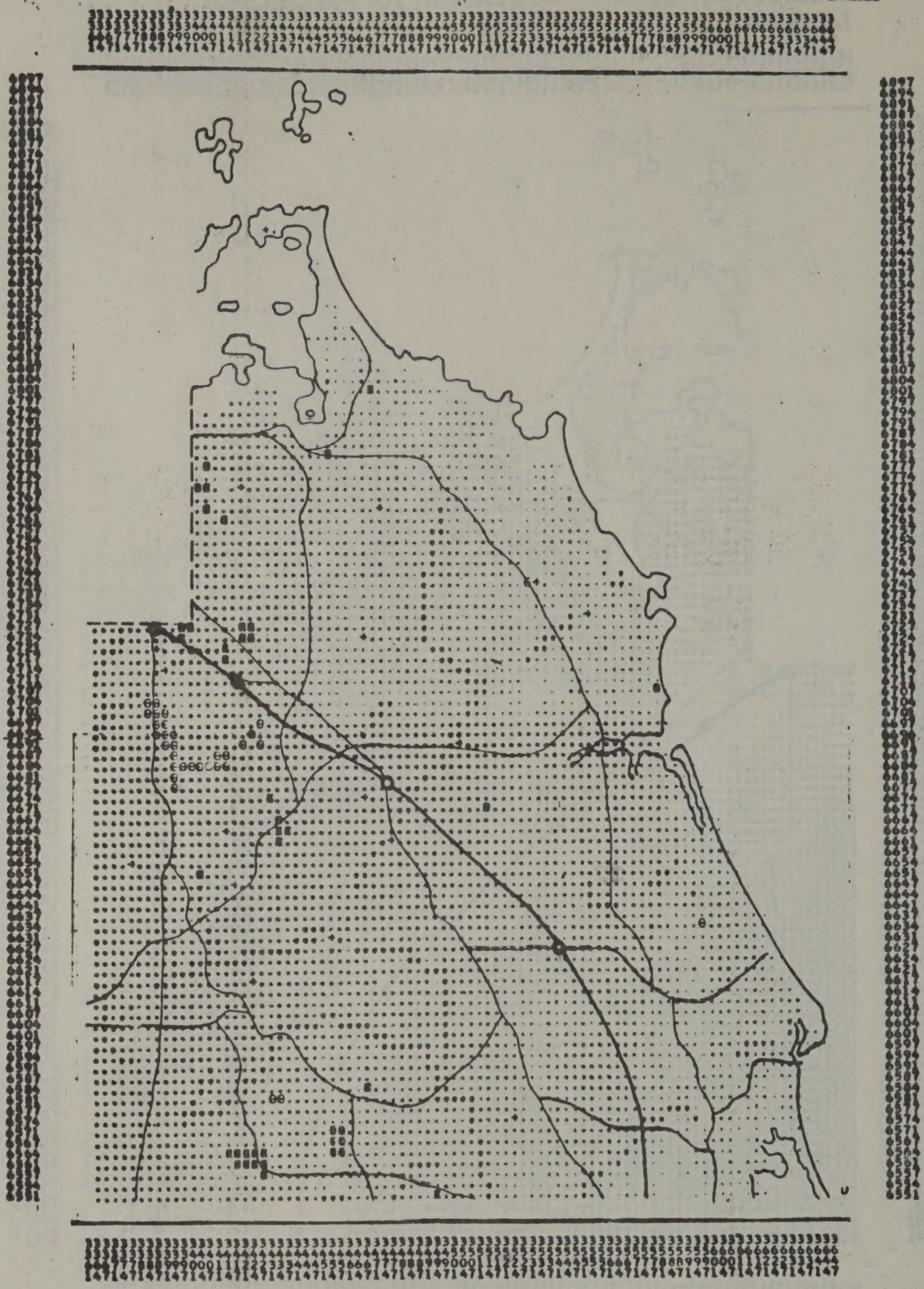
. 0 = None
, 1 = Unimproved Dirt Road
, 2 = Paved Light Duty
+ 3 = Paved Medium Duty
X 4 = Urban Streets
O 5 = Heavy Duty
⊖ 6 = Divided with Access
⊠ 8 = Divided with Limited Access
■ 9 = Interchange on Divided Highway with Limited Access

FIG. B.21 BOSTON REGION : SOUTHEAST SECTOR TRANSPORTATION - DISTANCE TO PROJECTED LIMITED ACCESS HIGHWAY



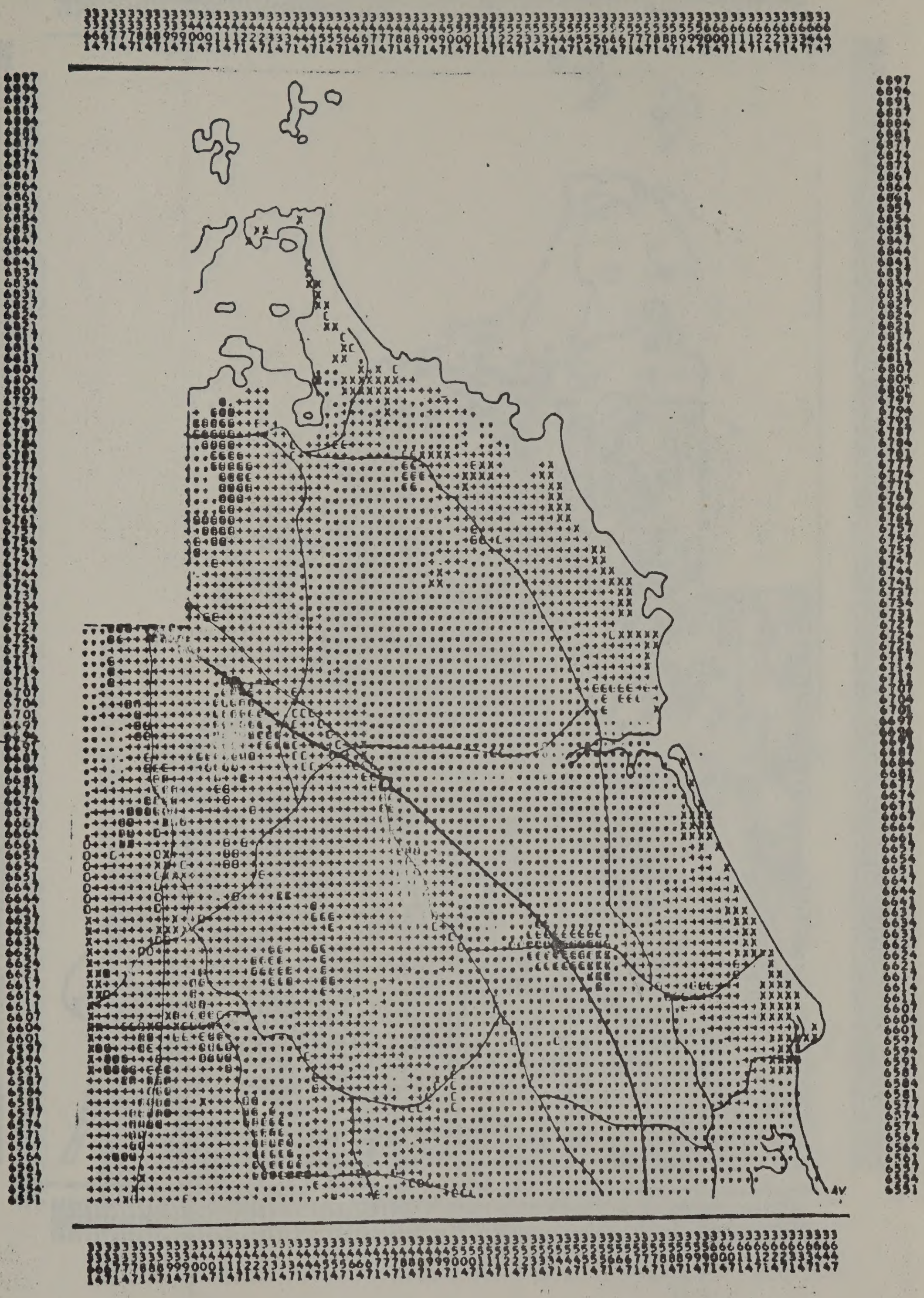
Each level indicates an increment of one kilometer from the highway.

FIG. B.22 BOSTON REGION : SOUTHEAST SECTOR
ENVIRONMENTAL NUISANCES - PREDOMINANT TYPE



. 0 = None
, 1 = Polluted Water
, 2 = Utility Wires Towers
+ 3 = Water Towers
X 4 = Transient Trailer Parks
O 5 = Prisons
θ 6 = Airports Level Lead Flight Zones
⊖ 7 = Sewerage Disposal Units
⊠ 8 = Dirty Industry
■ 9 = Garbage Disposal Units

FIG. B.23 BOSTON REGION : SOUTHEAST SECTOR
ZONING - PREDOMINANT TYPE



. 0 = No Change Permitted
, 1 = Recreation
, 2 = Residential, 1 acre & Above (min. lost size)
+ 3 = Residential, 15,000 sq. ft. to 1 acre
X 4 = Residential, 8000 squ. ft. to 14,000 sq. ft.
O 5 = Local Commerce
Θ 6 = General Commerce
⊖ 7 = Industry - Restricted
⊠ 8 = Industry - Unrestricted
■ 9 = No Zoning (unrestricted)

FIG. B.24 BOSTON REGION : SOUTHEAST SECTOR SUITABILITY FOR HIGH INCOME HOUSING

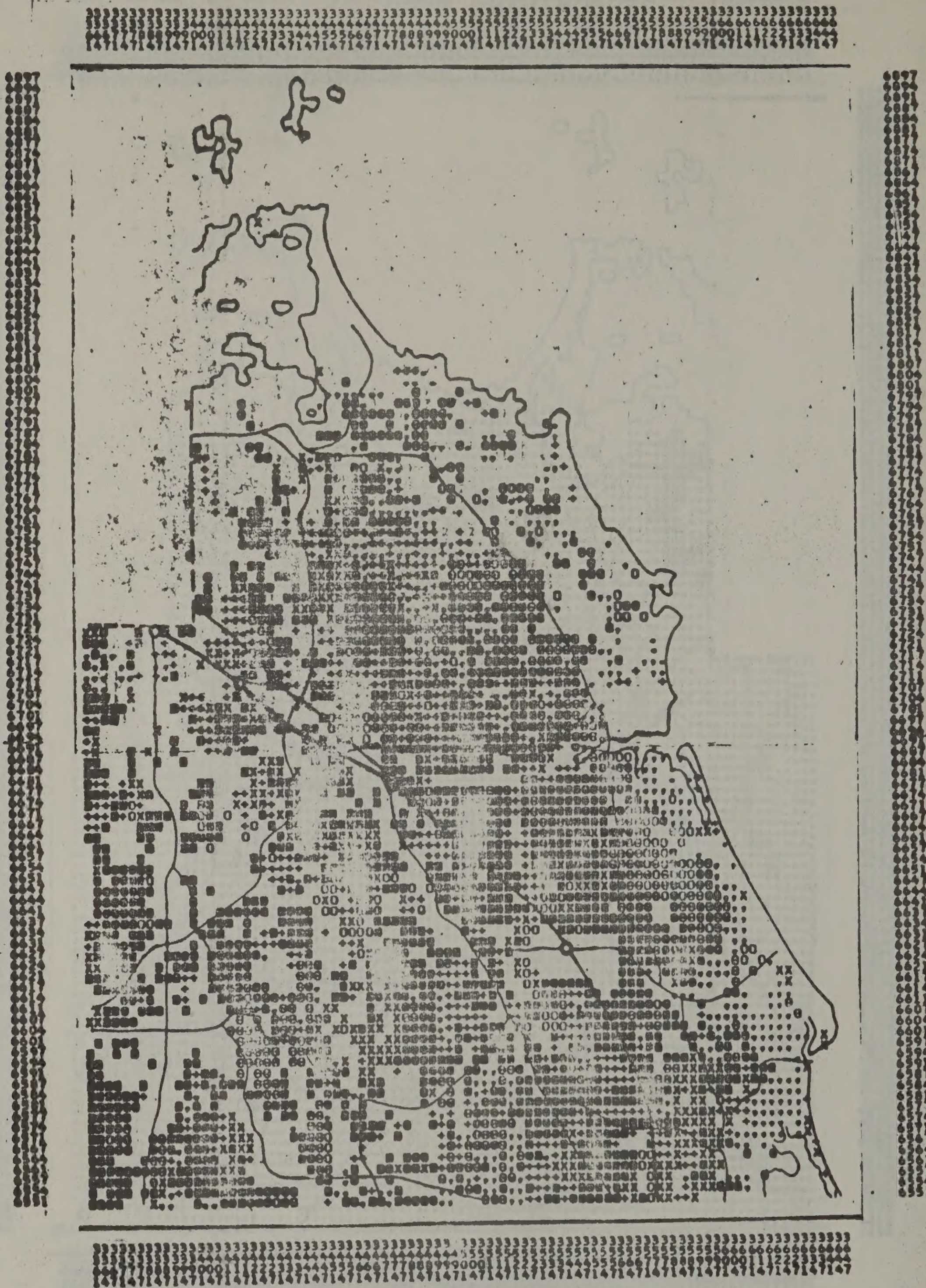


FIG. B.25 BOSTON REGION : SOUTHEAST SECTOR SUITABILITY FOR MEDIUM INCOME HOUSING

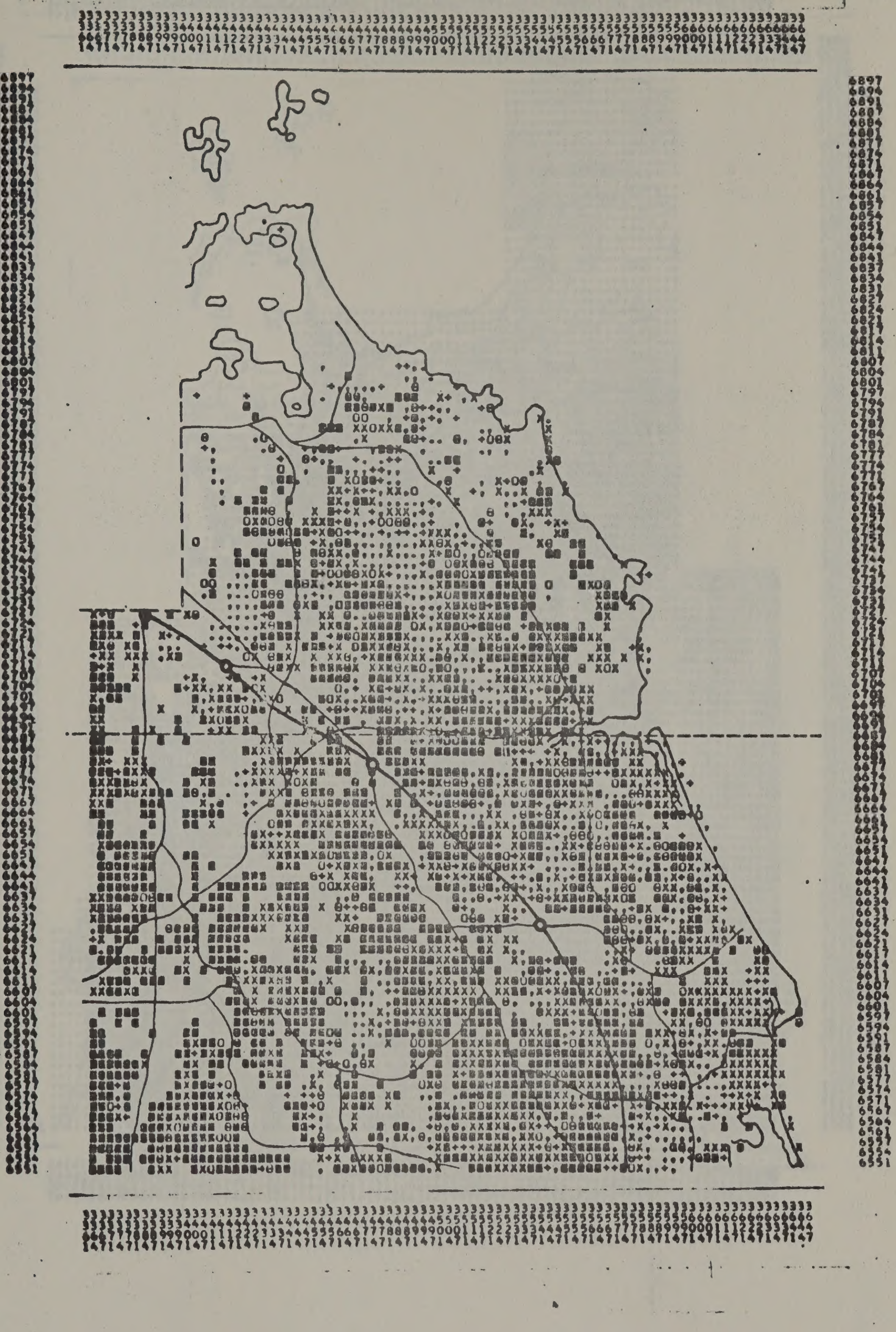


FIG. B.26 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR LOW INCOME HOUSING

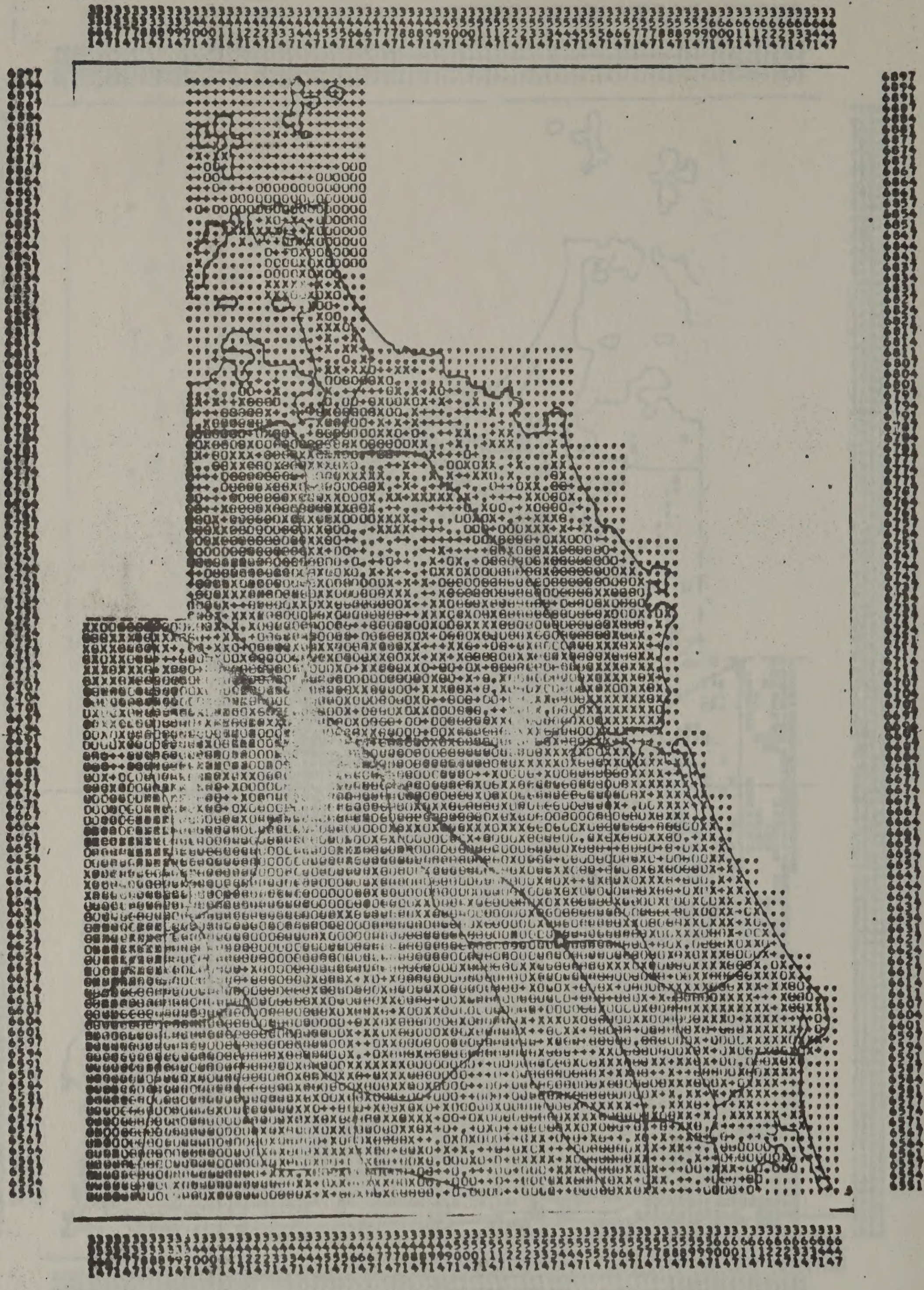


FIG. B.27 BOSTON REGION : SOUTHEAST SECTOR
SITE CONSTRUCTION COSTS FOR INDUSTRY

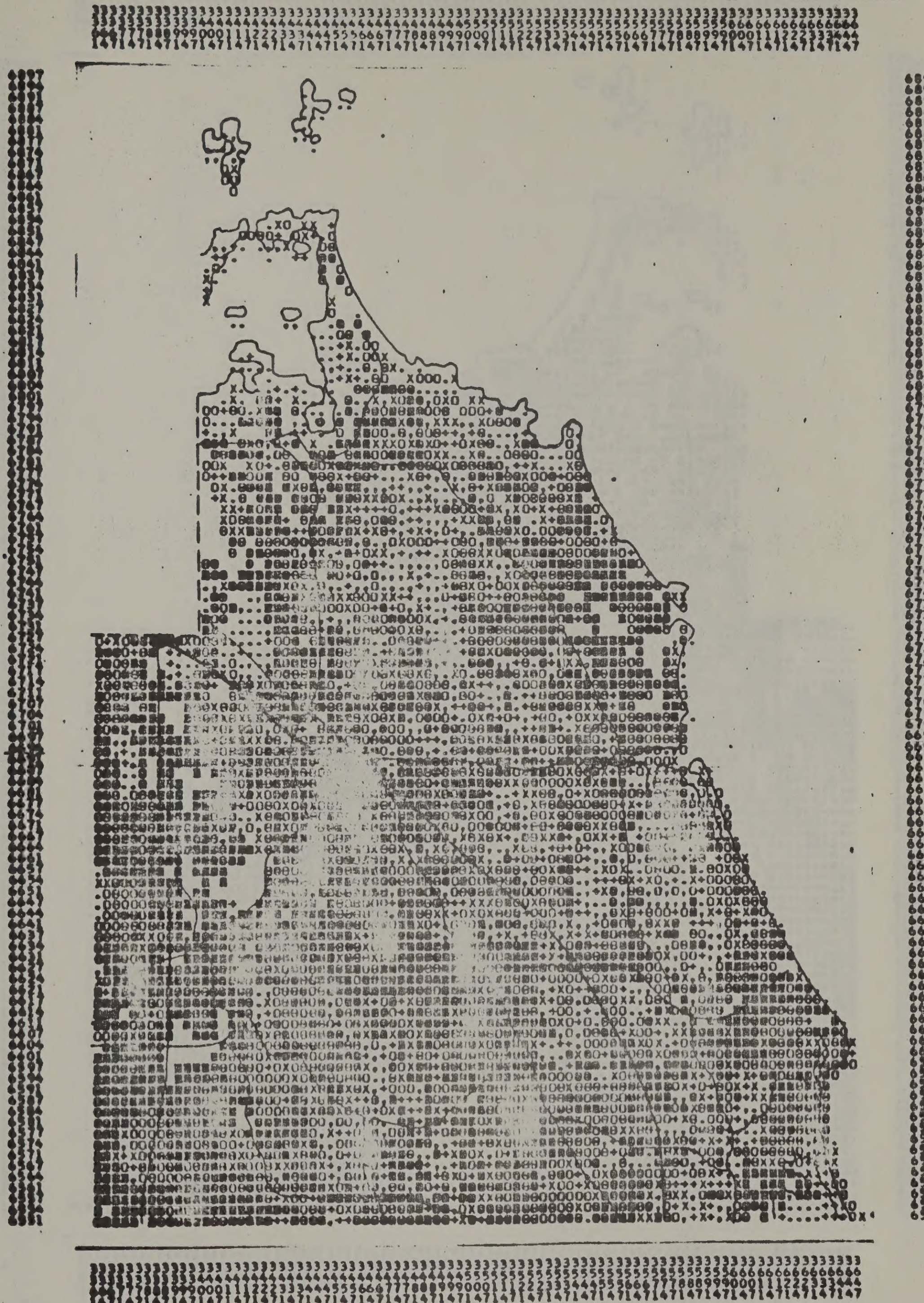
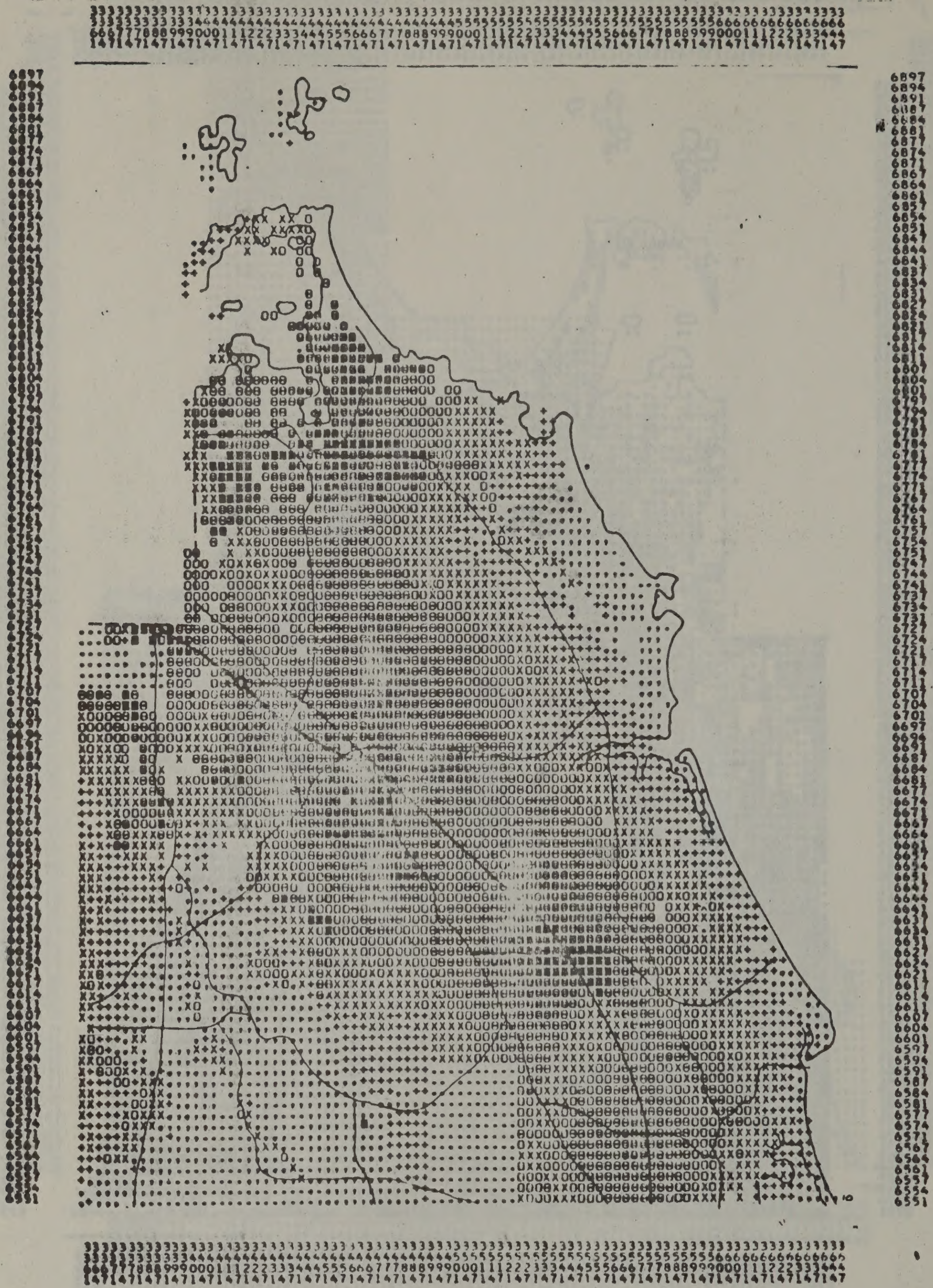


FIG. B.28 BOSTON REGION : SOUTHEAST SECTOR ACCESS AND TOWN COSTS FOR INDUSTRY



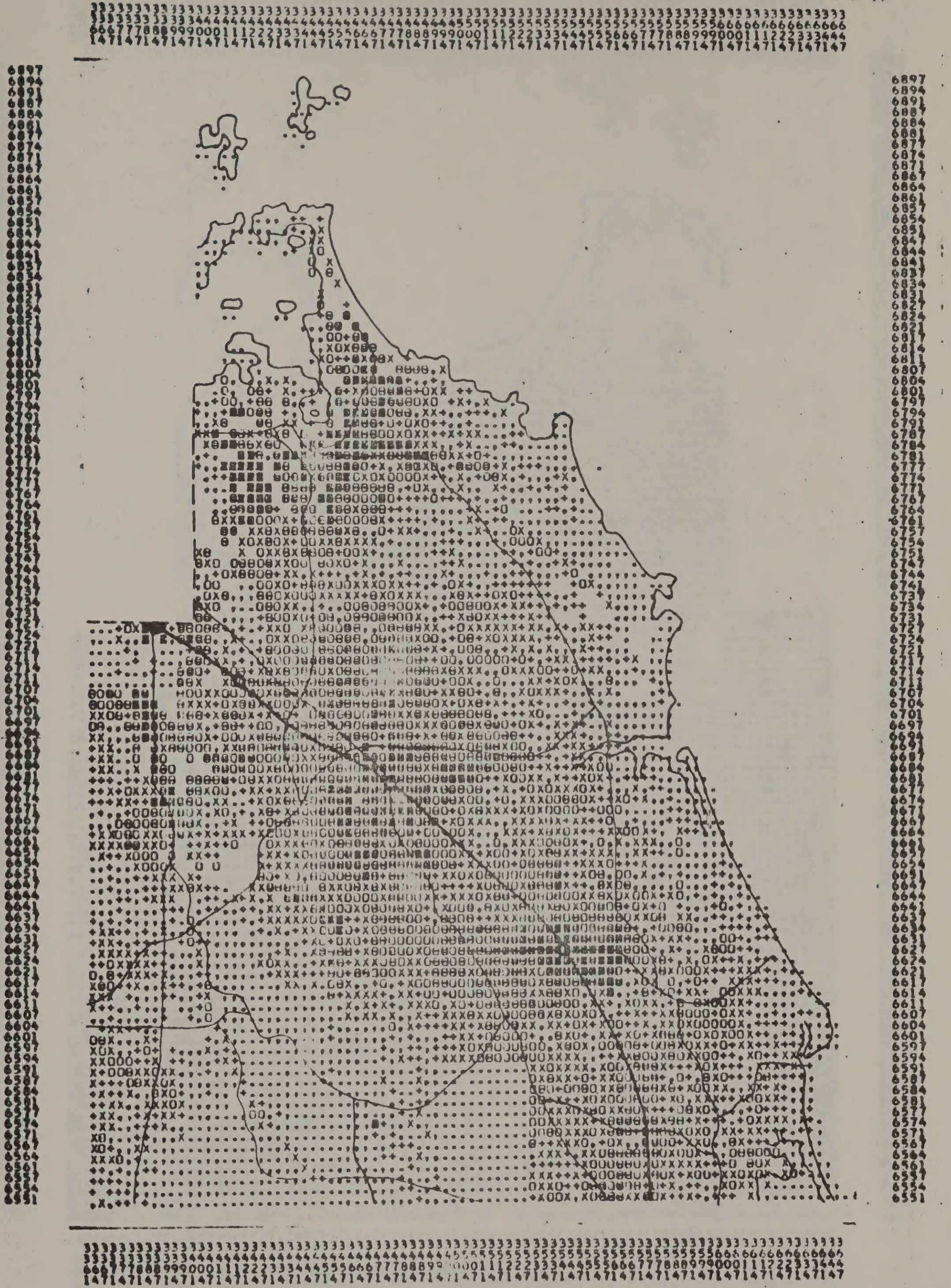


FIG. B.29 BOSTON REGION : SOUTHEAST SECTOR
COMPOSITE COST MAP FOR INDUSTRY

FIG. B.30 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR REGIONAL COMMERCIAL CENTERS

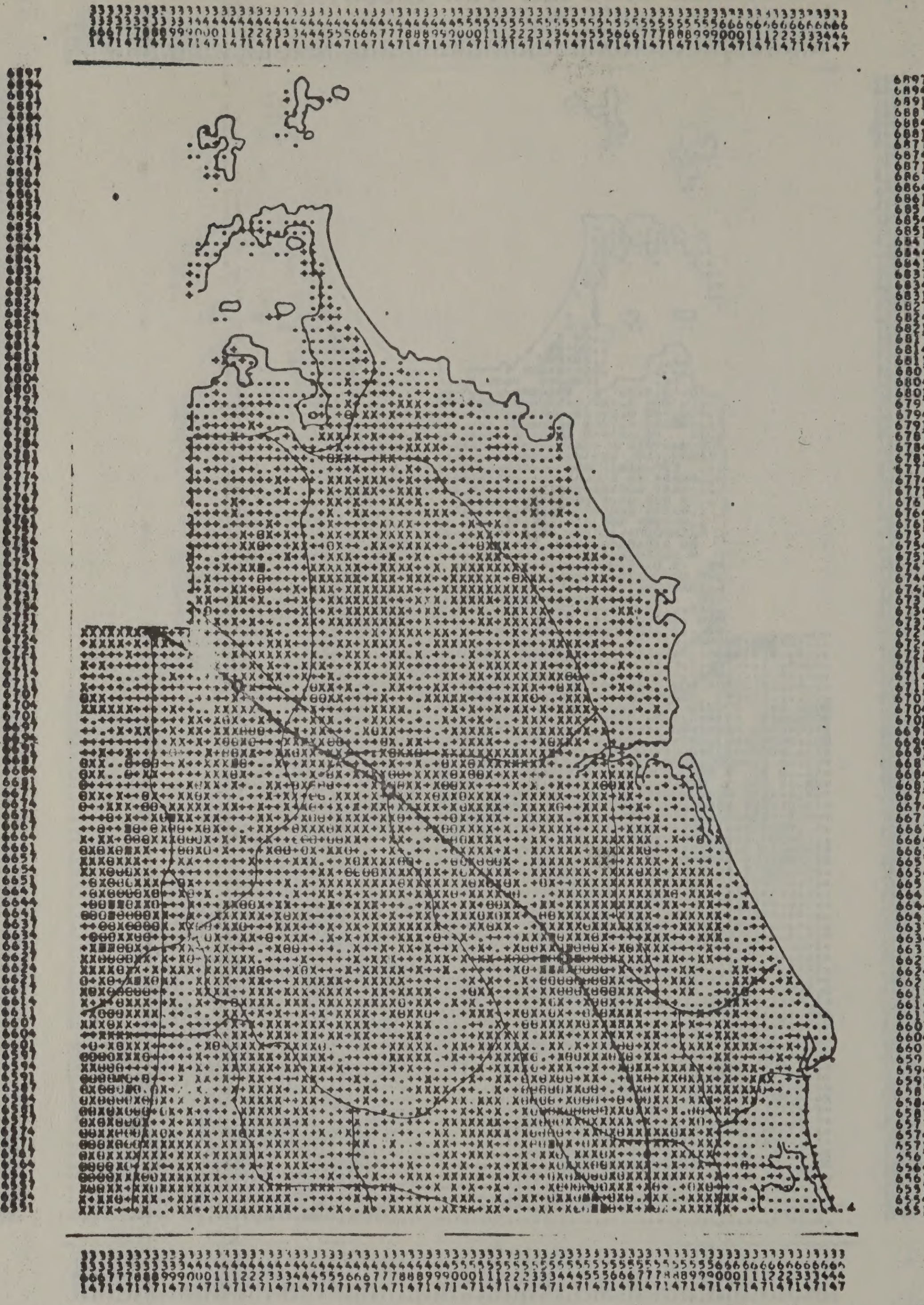


FIG. B.31 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR HOSPITALS

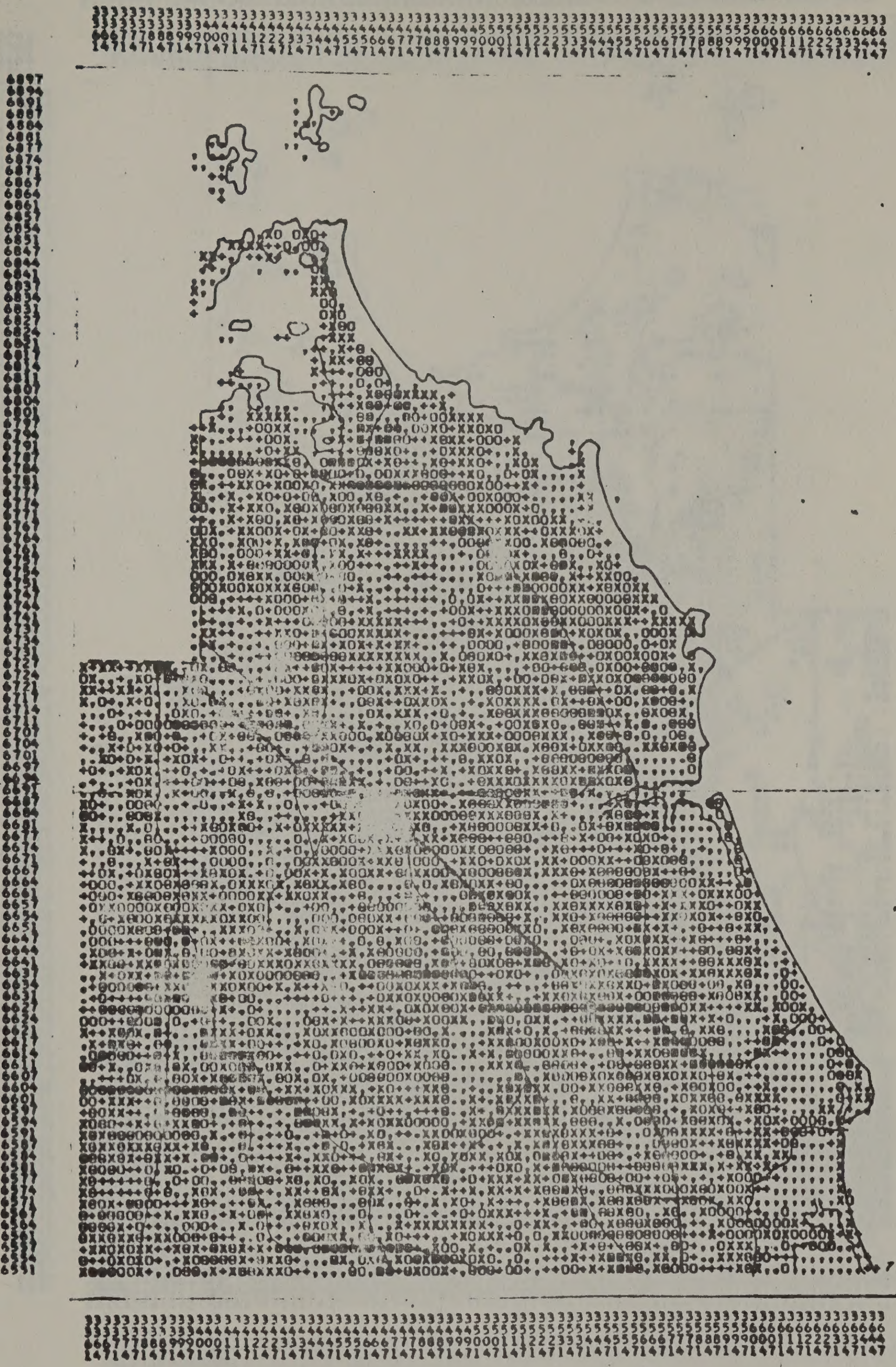


FIG. B.32 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR COMMUNITY COLLEGES

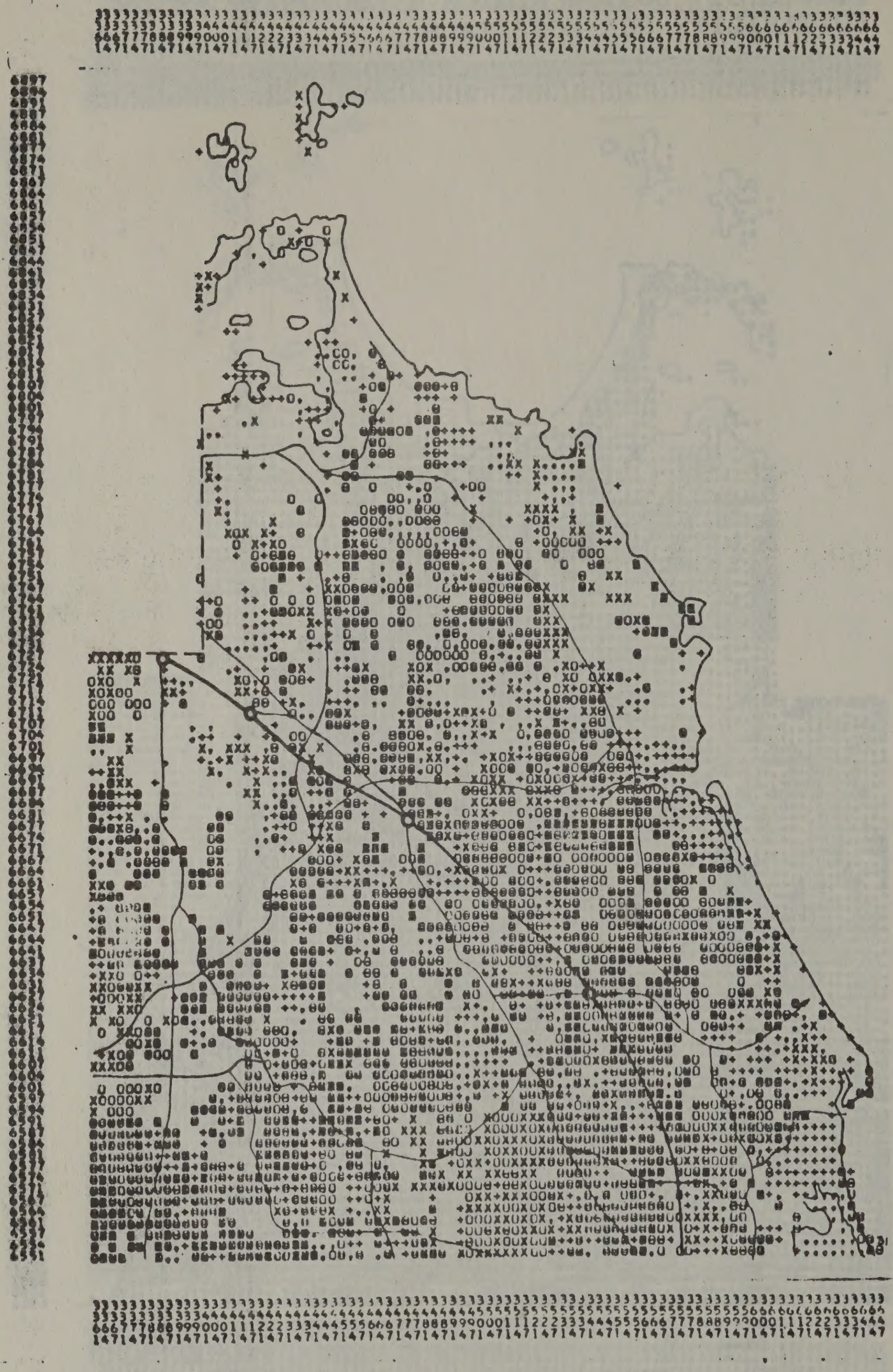


FIG. B.33 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR MASS TRANSIT INTERCHANGE

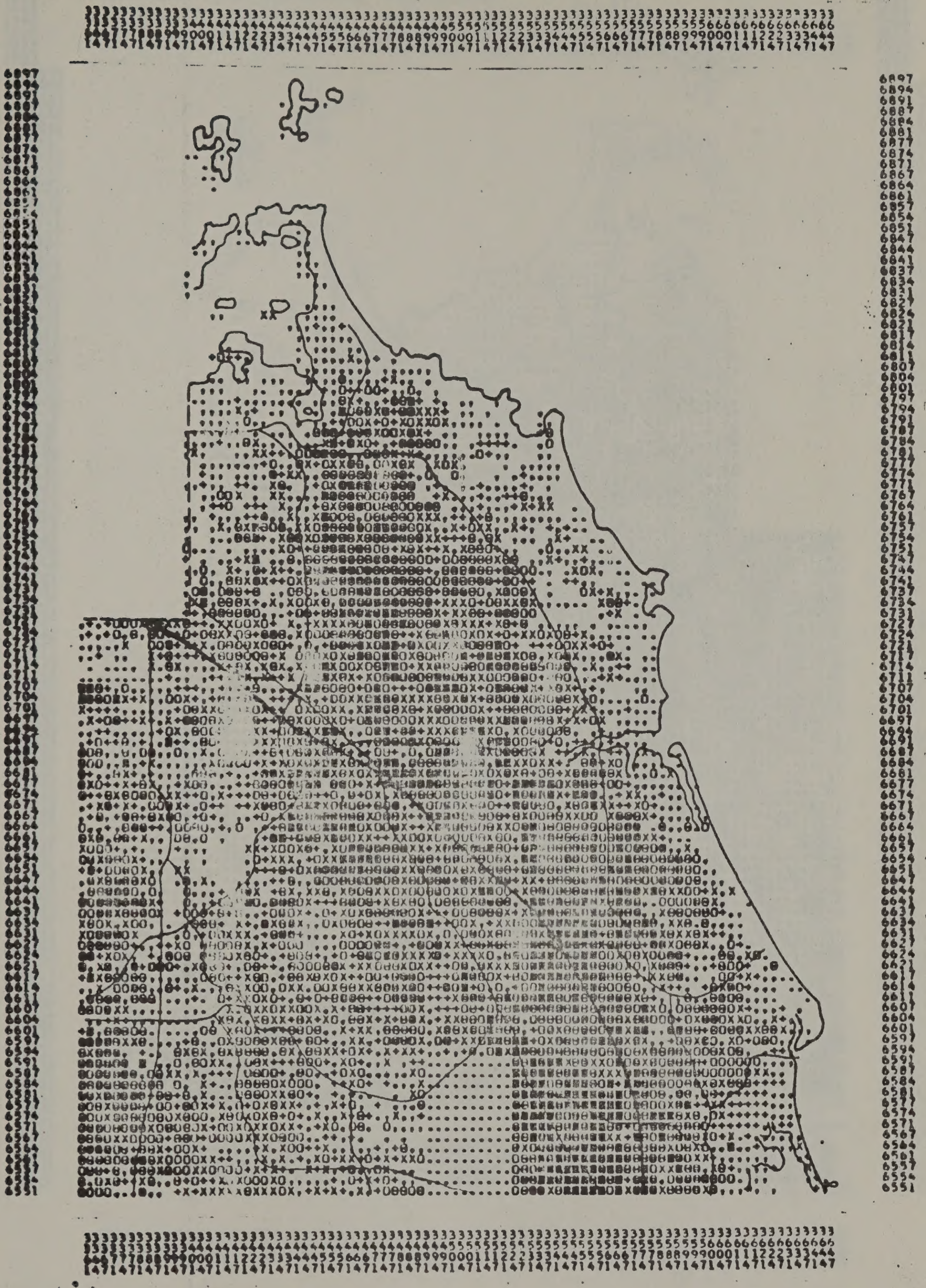


FIG. B.34 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR A REGIONAL AIRPORT
BASED ON PHYSICAL FACTORS

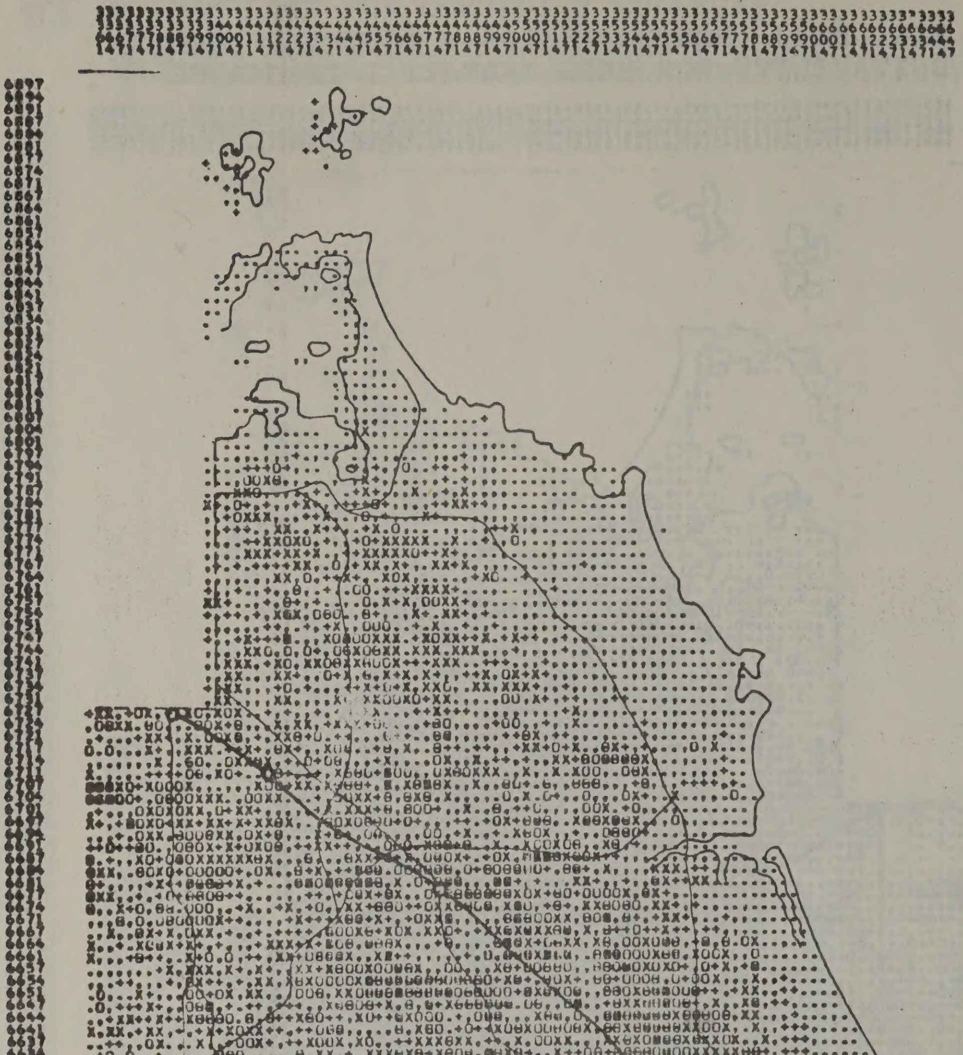


FIG. B.35 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR A REGIONAL AIRPORT
BASED ON SOCIAL FACTORS

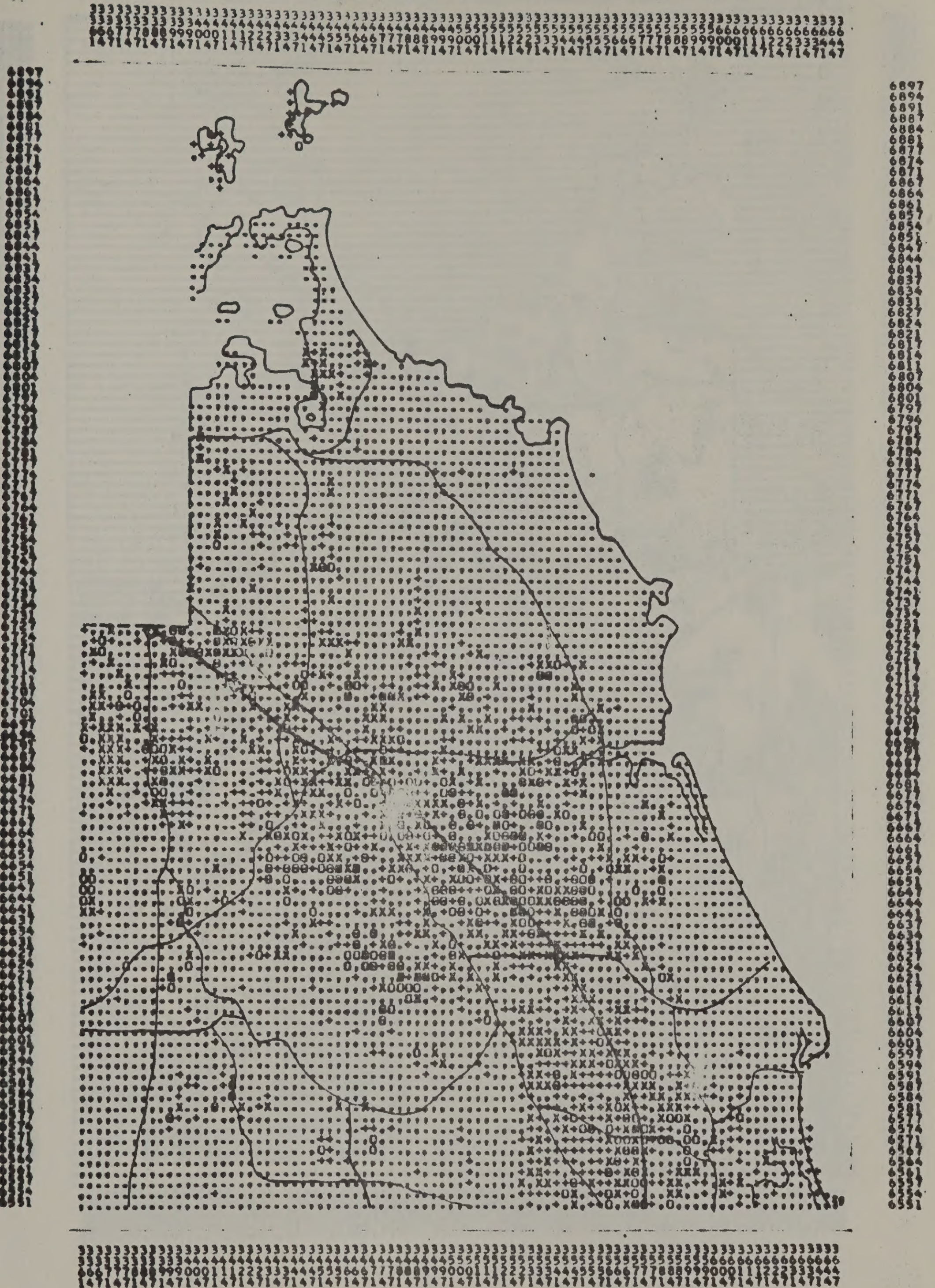


FIG. B.36 BOSTON REGION : SOUTHEAST SECTOR SUITABILITY FOR COMMERCIAL RECREATION

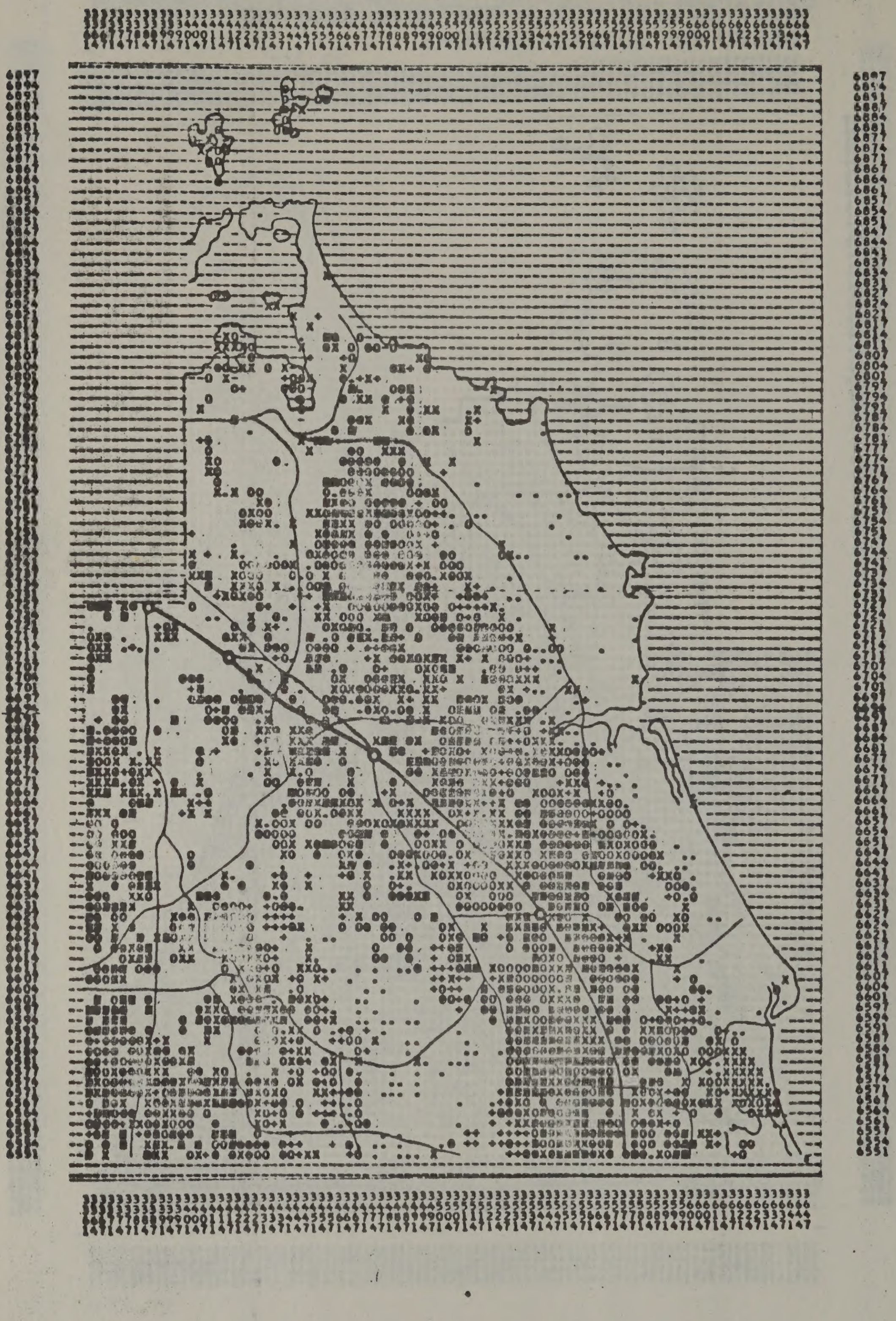


FIG. B.37 BOSTON REGION : SOUTHEAST SECTOR
ATTRACTIVENESS FOR LAND TRAILS

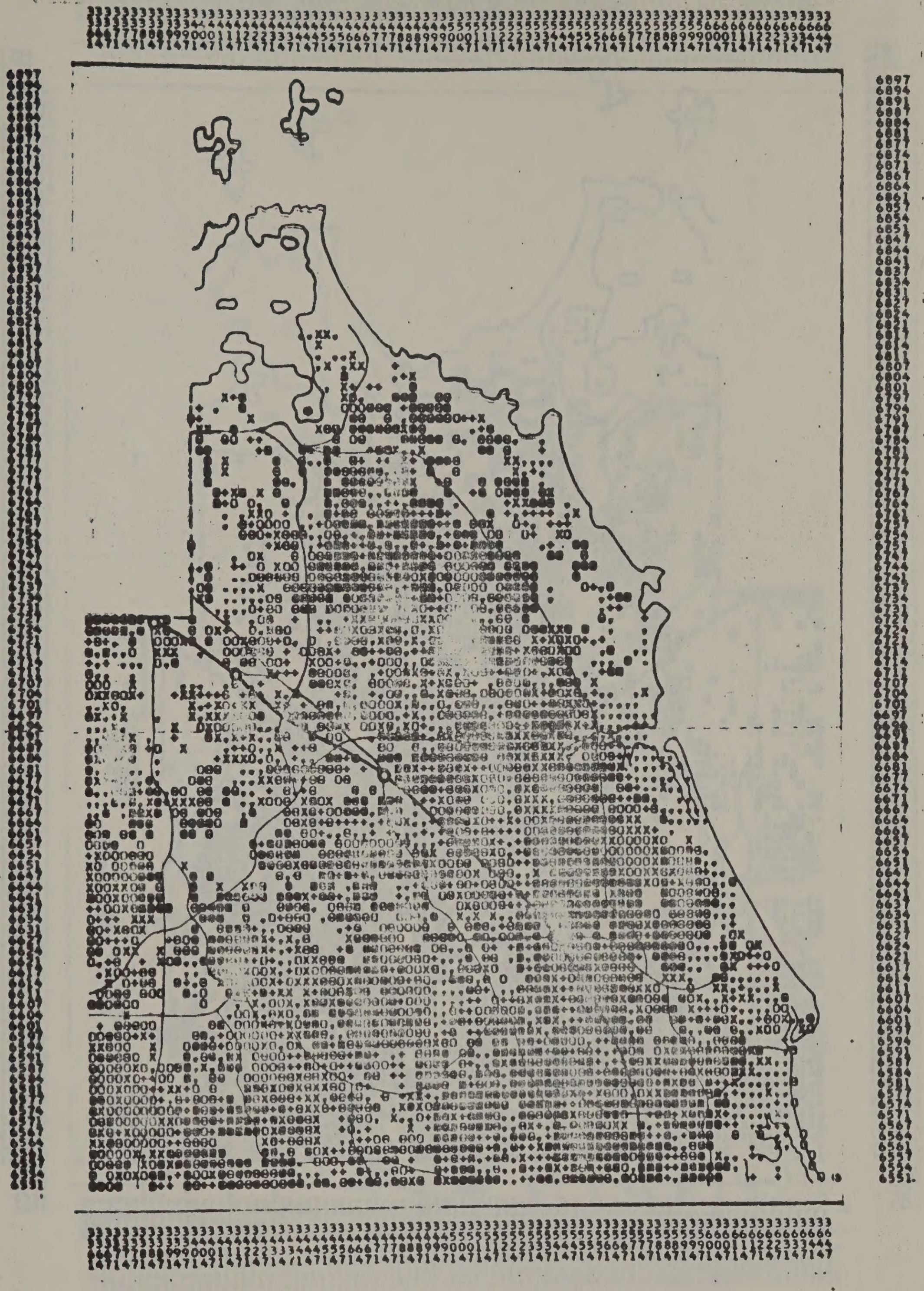


FIG. B.38 BOSTON REGION : SOUTHEAST SECTOR
ATTRACTIVENESS FOR CAMPING SITES

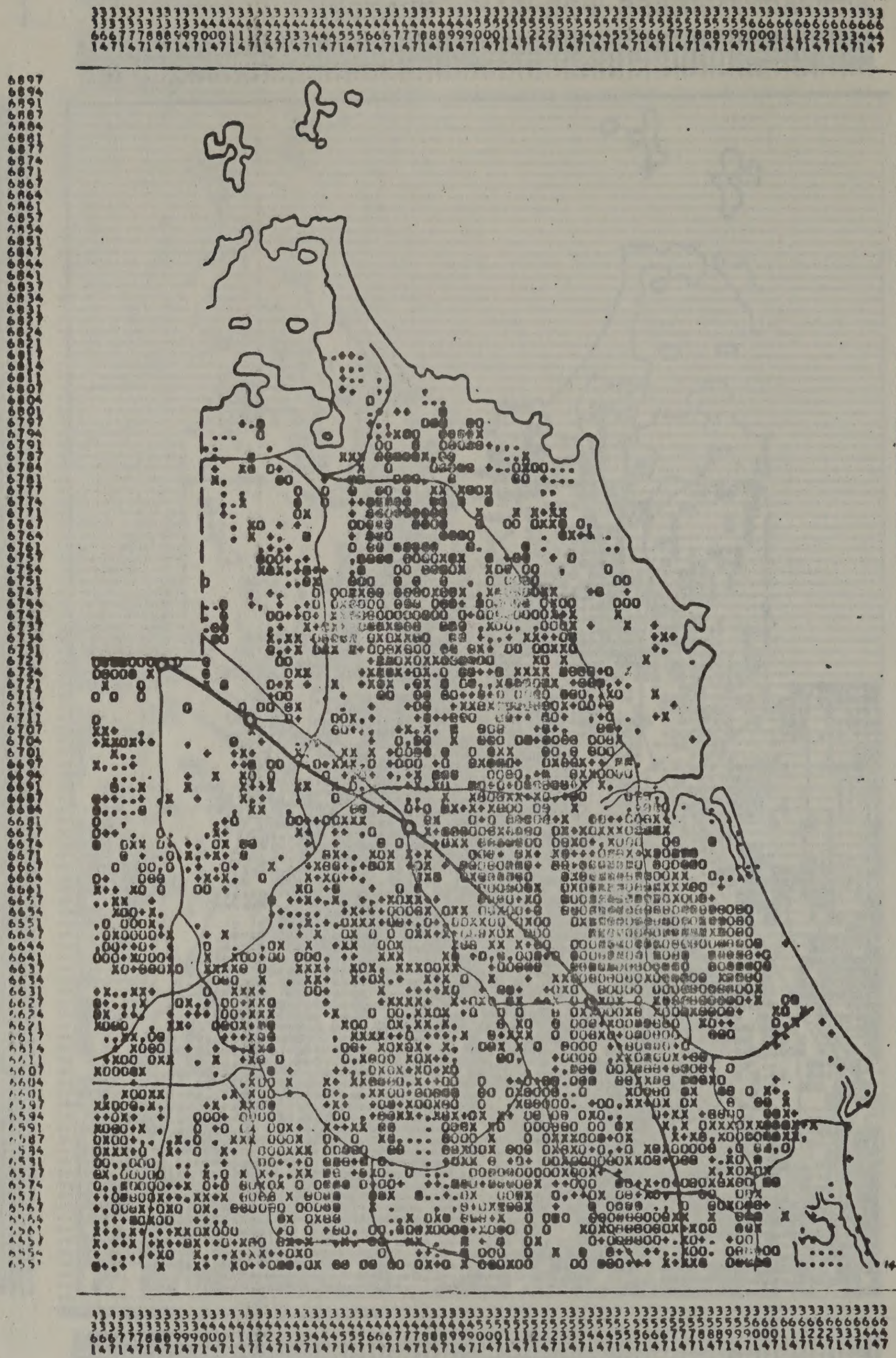


FIG. B.39 BOSTON REGION : SOUTHEAST SECTOR ATTRACTIVENESS FOR WATER TRAILS

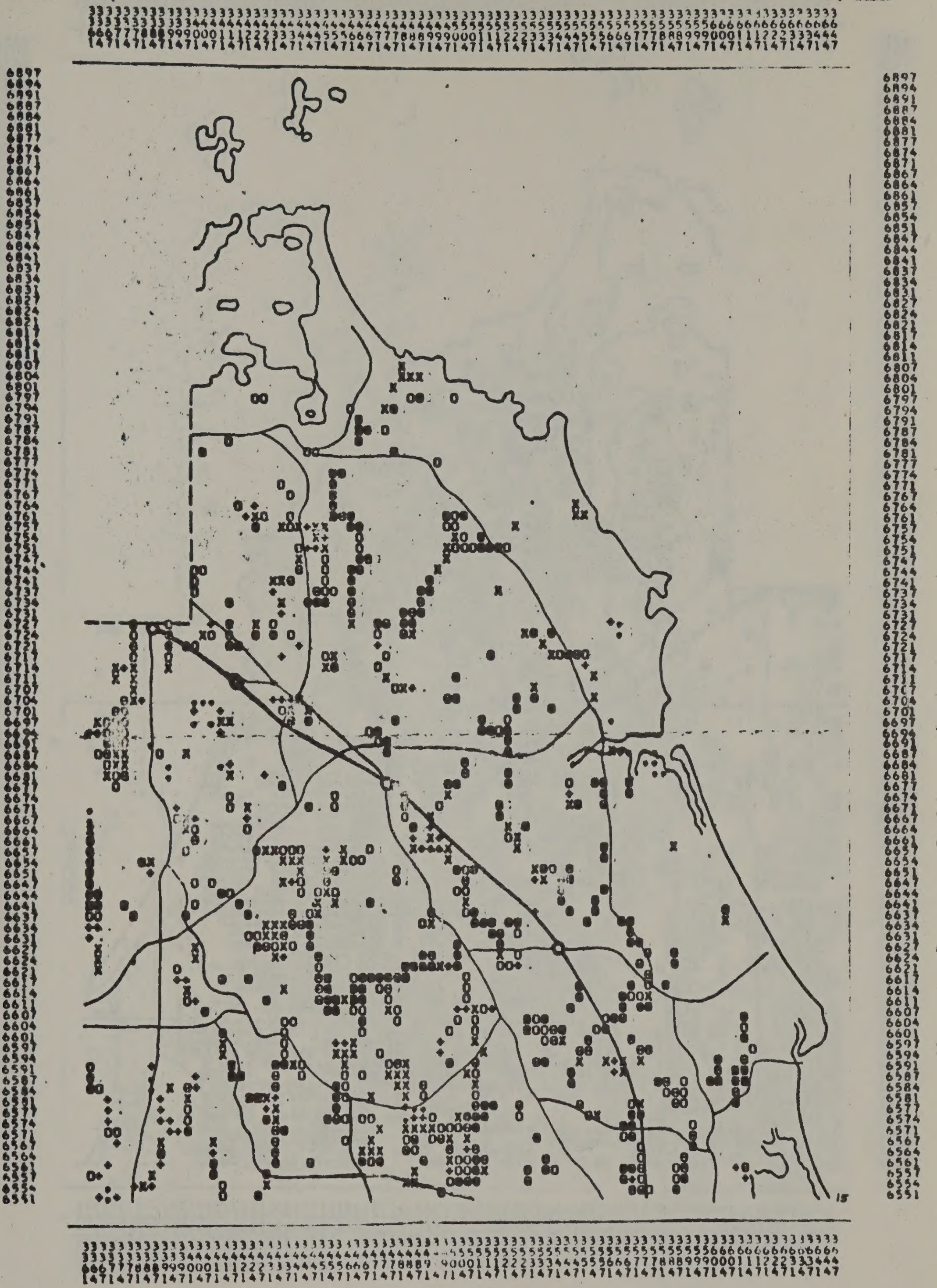


FIG. B.40 BOSTON REGION : SOUTHEAST SECTOR COMPOSITE OF ATTRACTIVENESS FOR OUTDOOR RECREATION ACTIVITIES

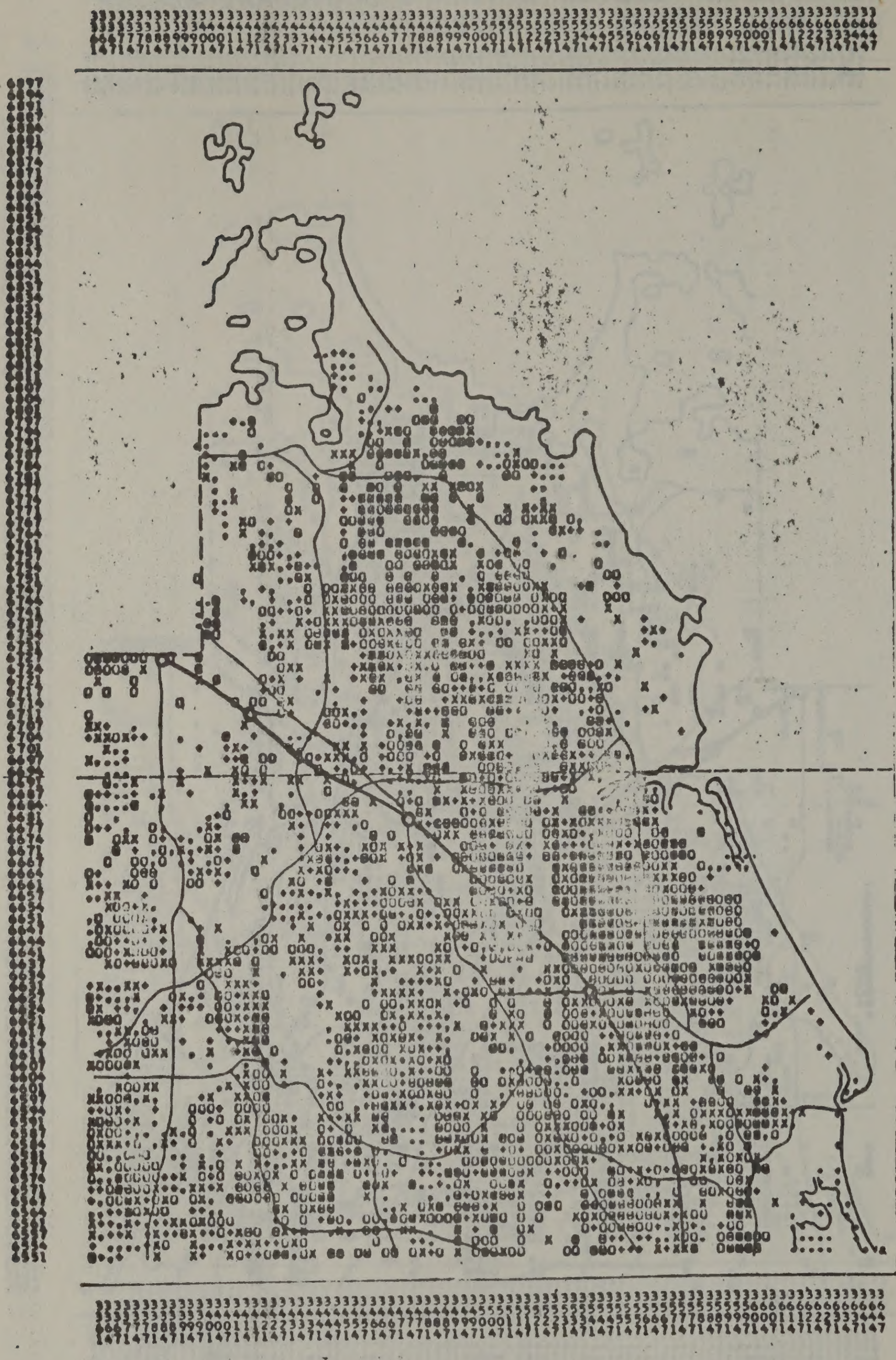


FIG. B.41 BOSTON REGION : SOUTHEAST SECTOR
SUITABILITY FOR A STATE PARK

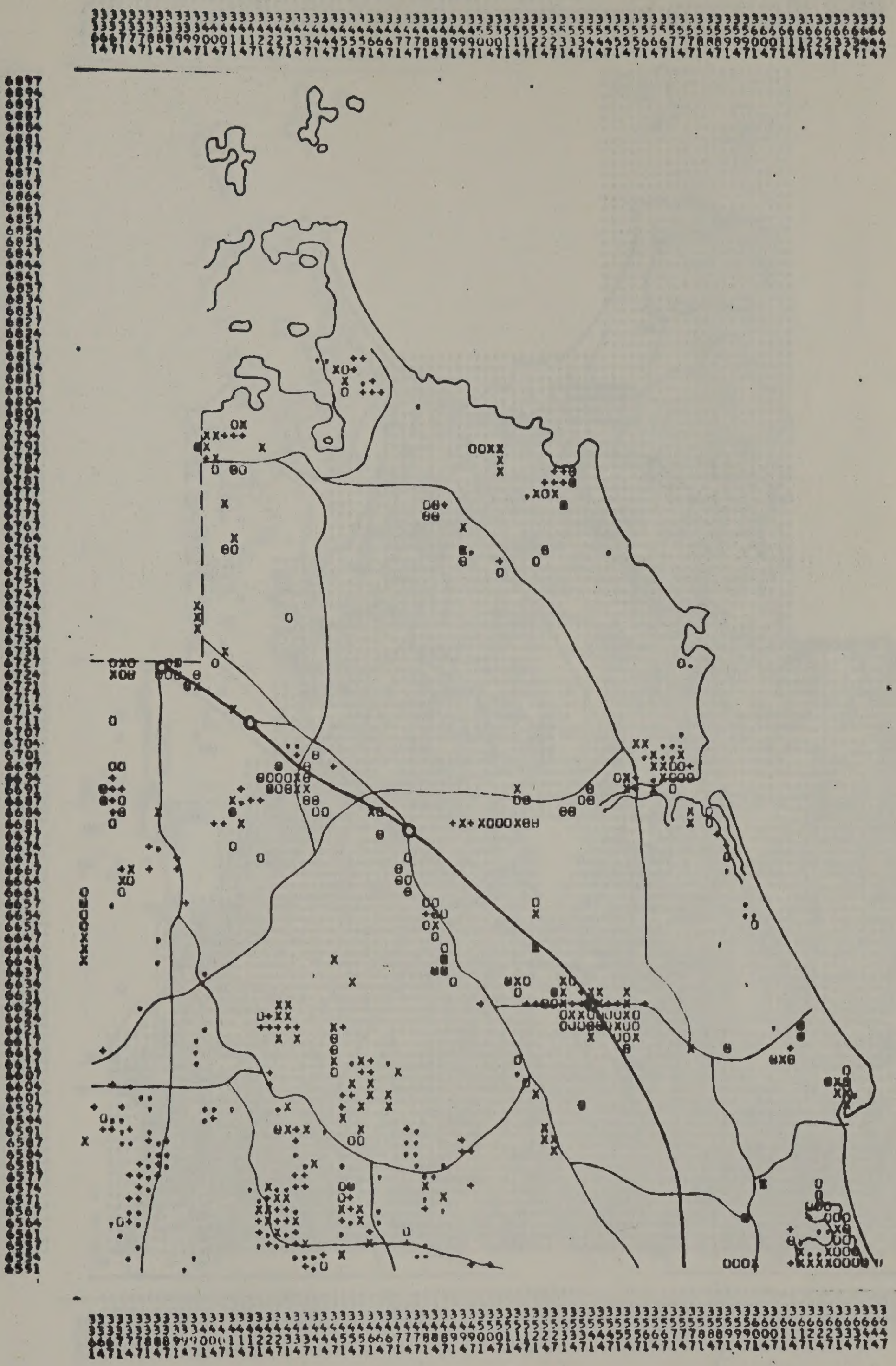


FIG. B.42 BOSTON REGION : SOUTHEAST SECTOR ATTRACTIVENESS FOR CONSERVATION

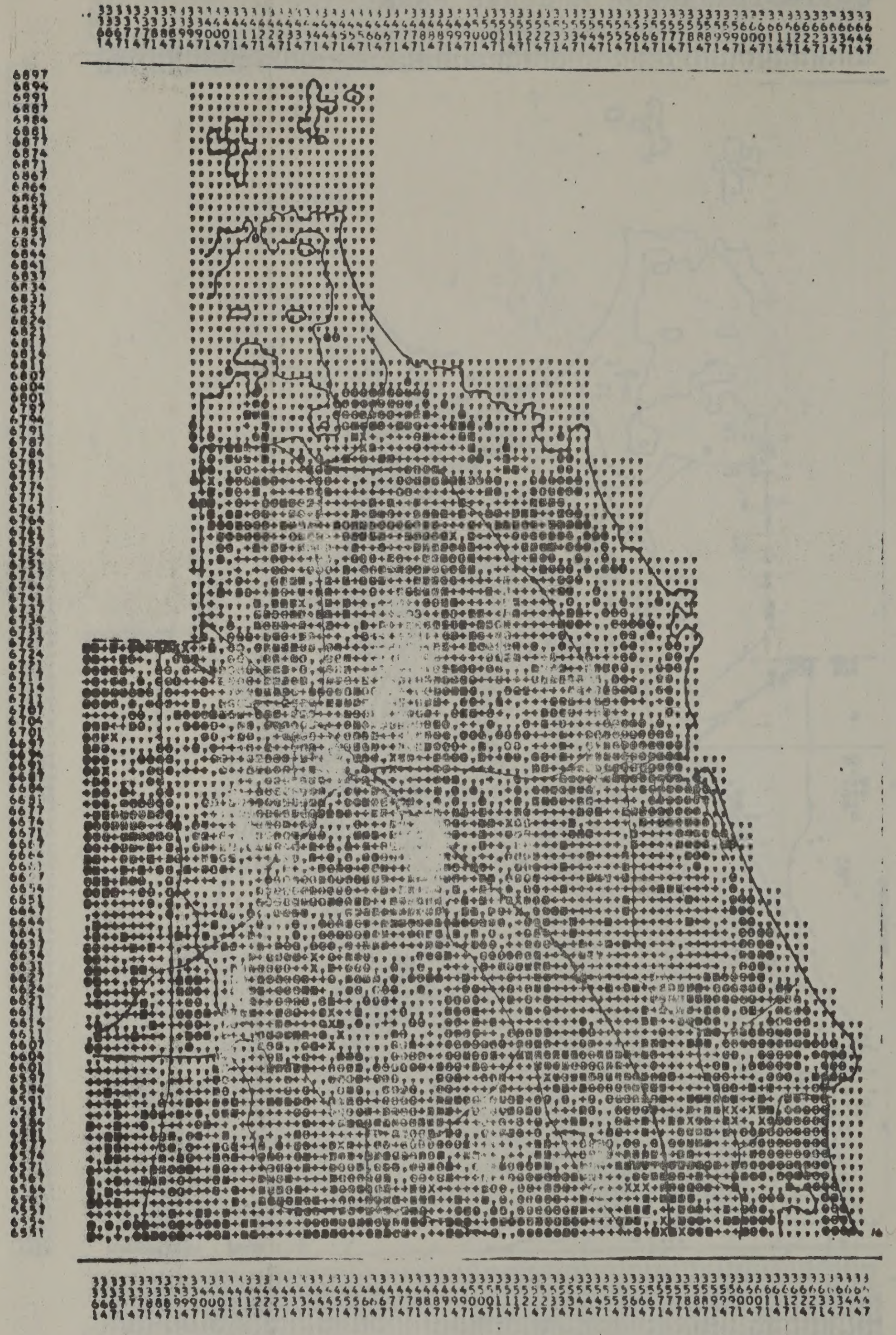


FIG. B.43 BOSTON REGION : SOUTHEAST SECTOR ATTRACTIVENESS OF FORESTS FOR CONSERVATION

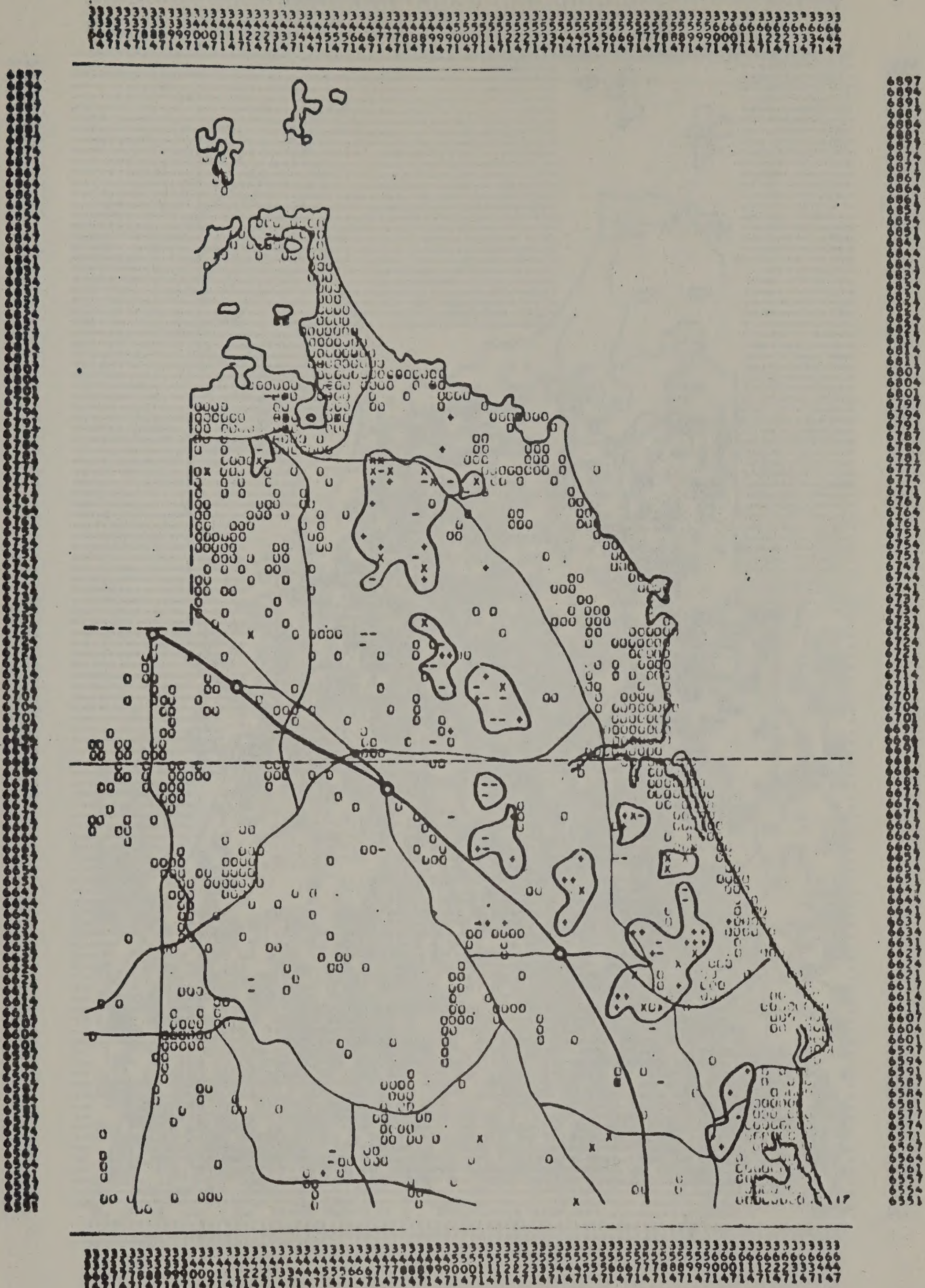


FIG. B.44 BOSTON REGION : SOUTHEAST SECTOR
POTENTIAL WILDLIFE HABITAT

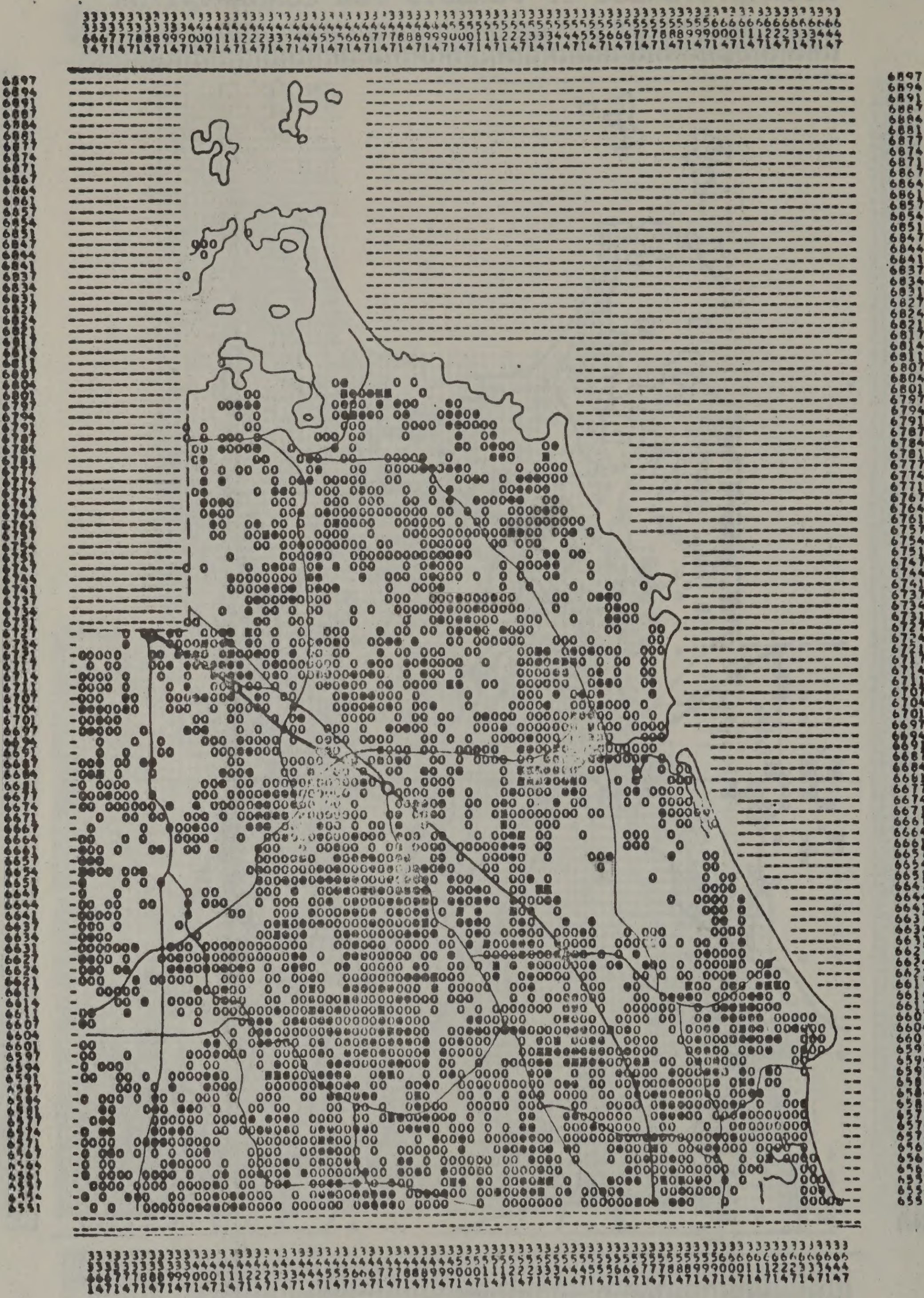


FIG. B.45 BOSTON REGION : SOUTHEAST SECTOR ECOLOGICAL STABILITY

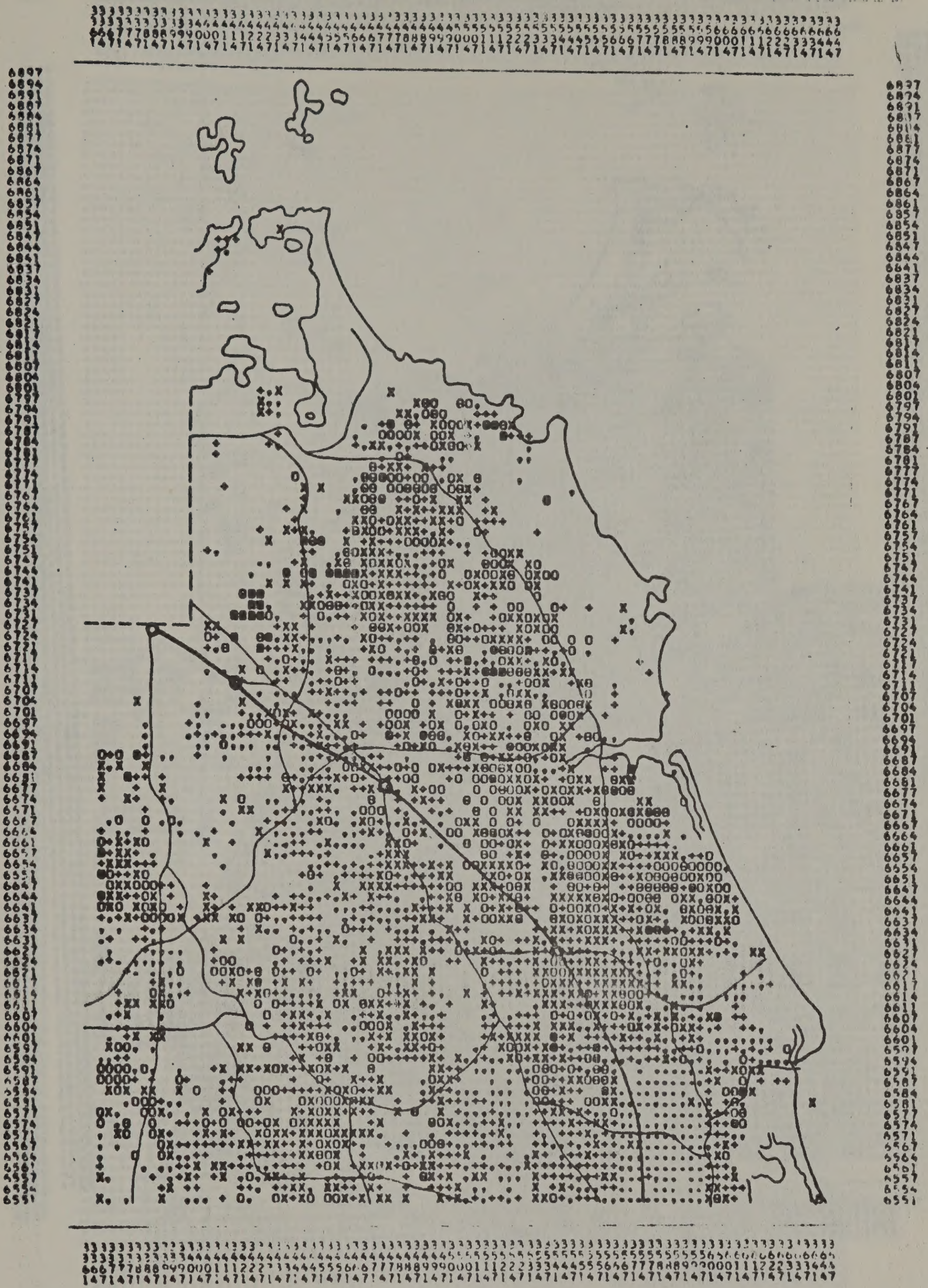


FIG. B.46 BOSTON REGION : SOUTHEAST SECTOR ECOLOGICAL STABILITY

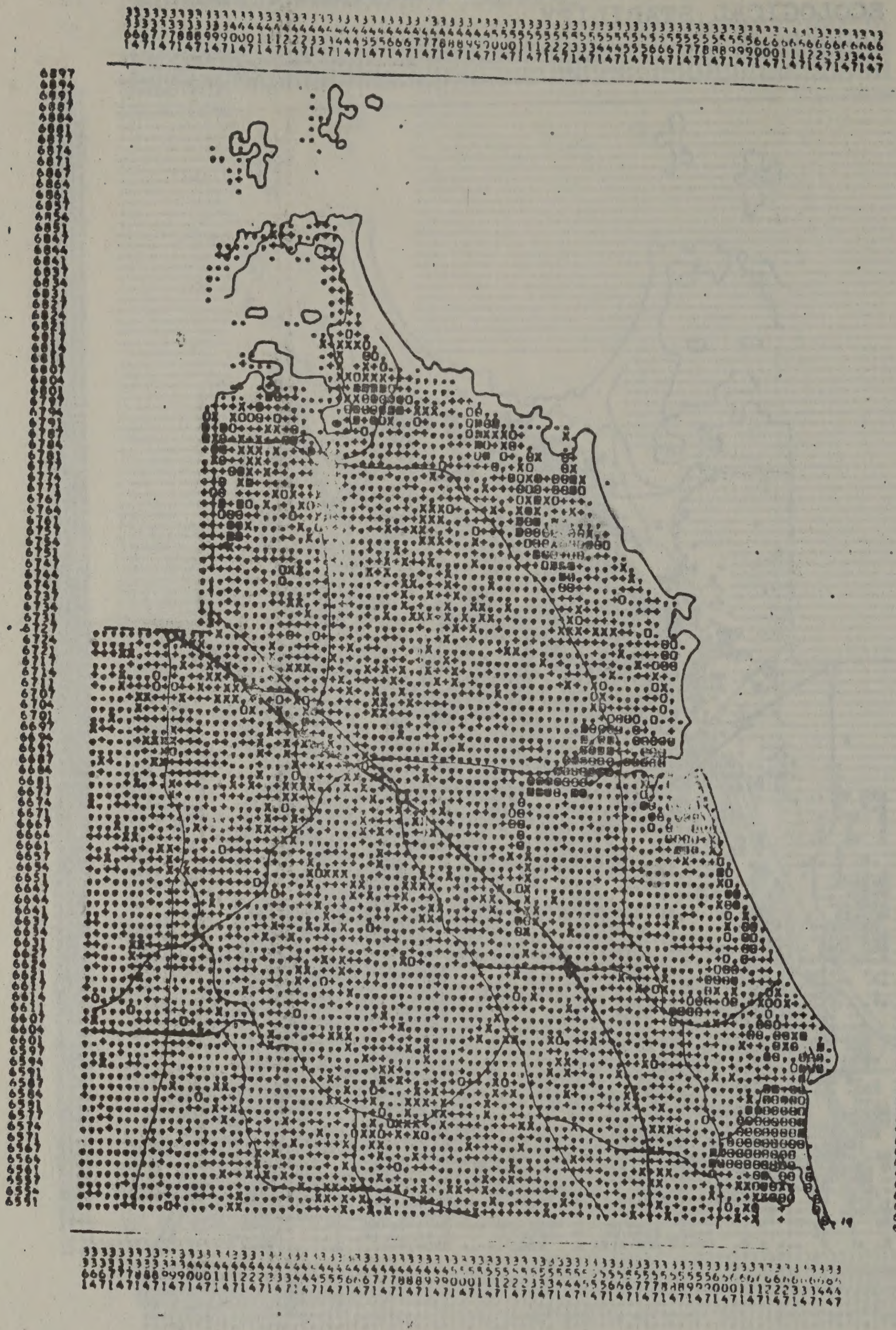


FIG. B.47 BOSTON REGION : SOUTHEAST SECTOR
PRESSURE ON WETLANDS FOR FILLING

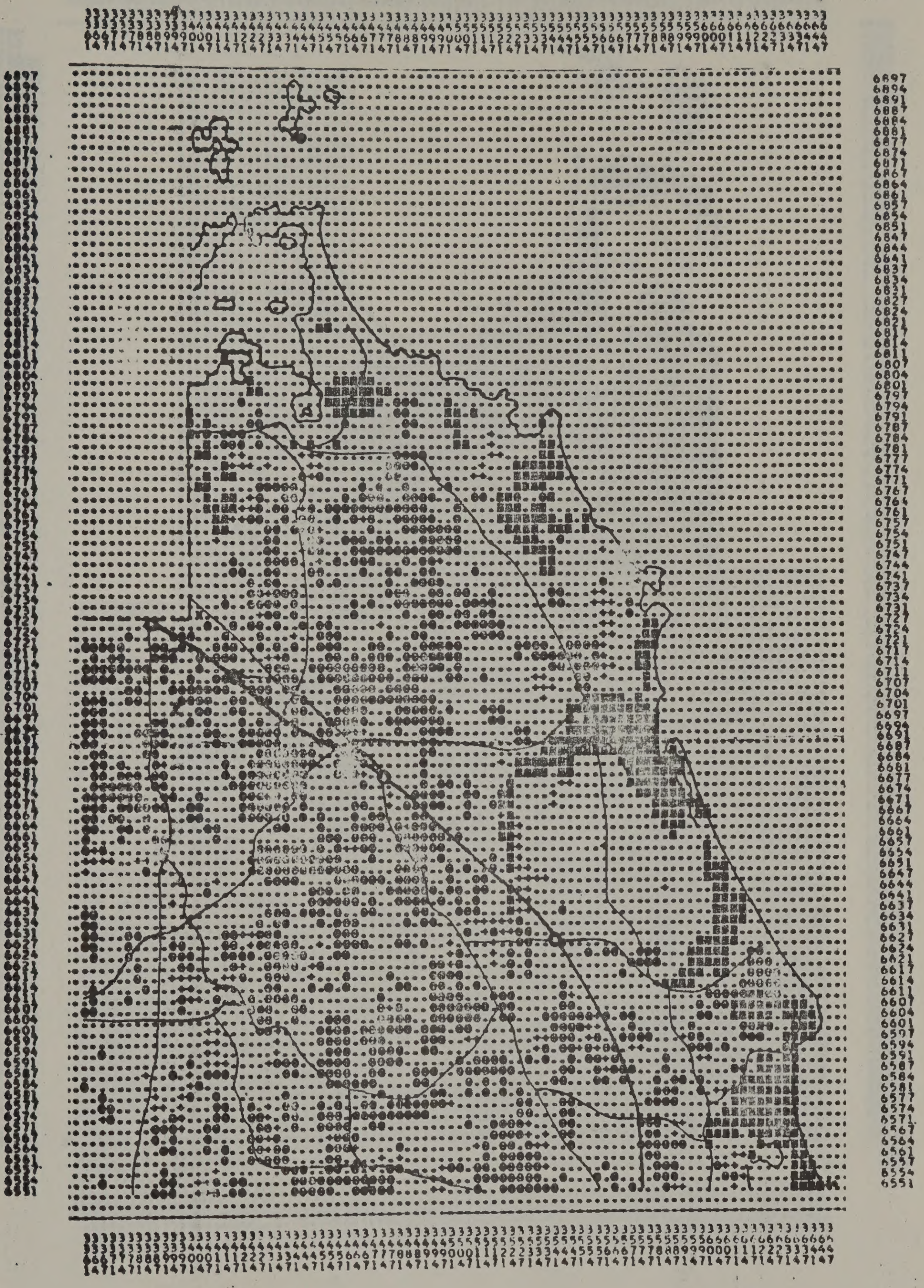


FIG. B.48 BOSTON REGION : SOUTHEAST SECTOR
VULNERABILITY TO SEPTIC TANK POLLUTION

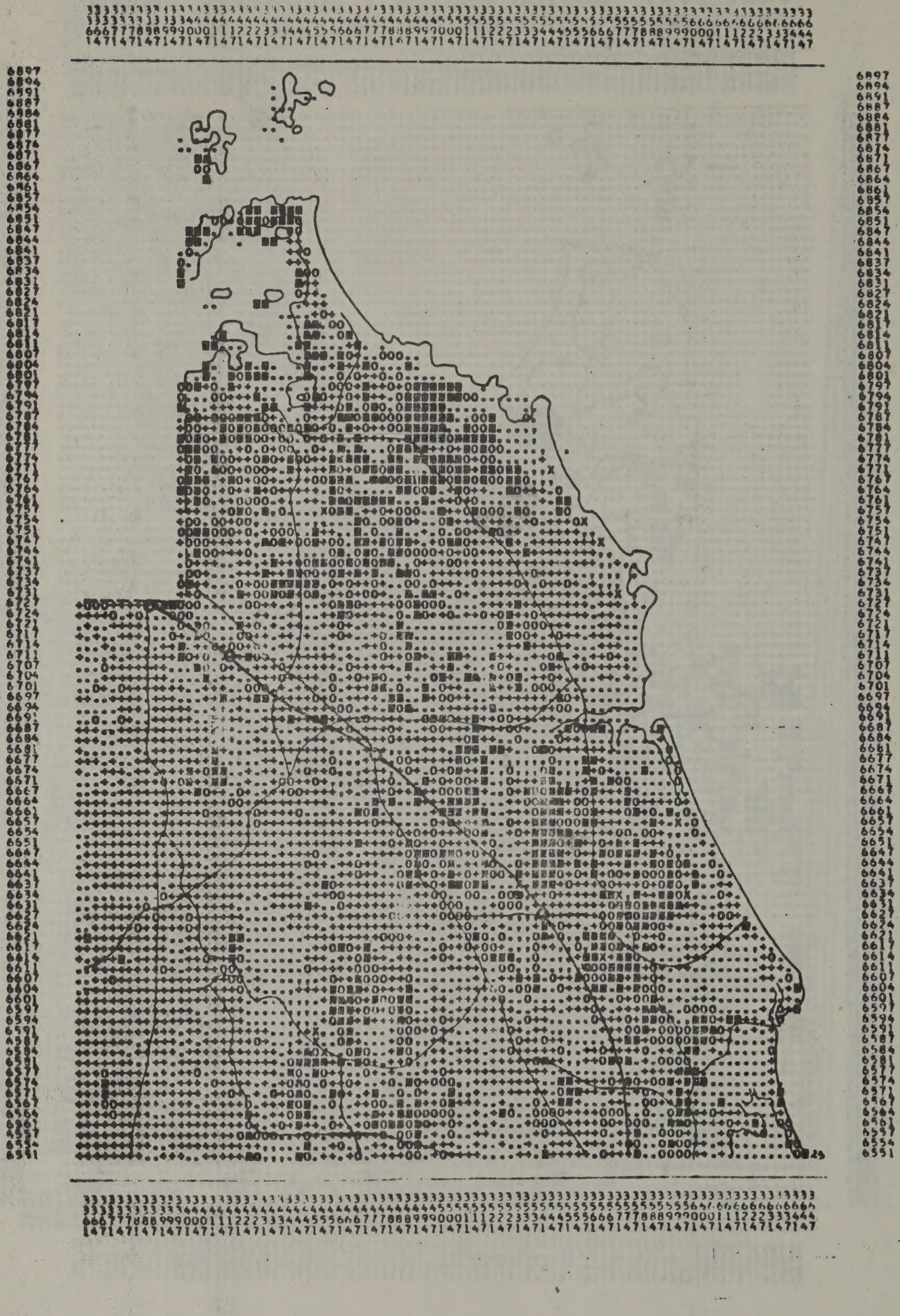


FIG. B.49 BOSTON REGION : SOUTHEAST SECTOR
RELATIVE STORM WATER RUN-OFF IN A HEAVY RAIN

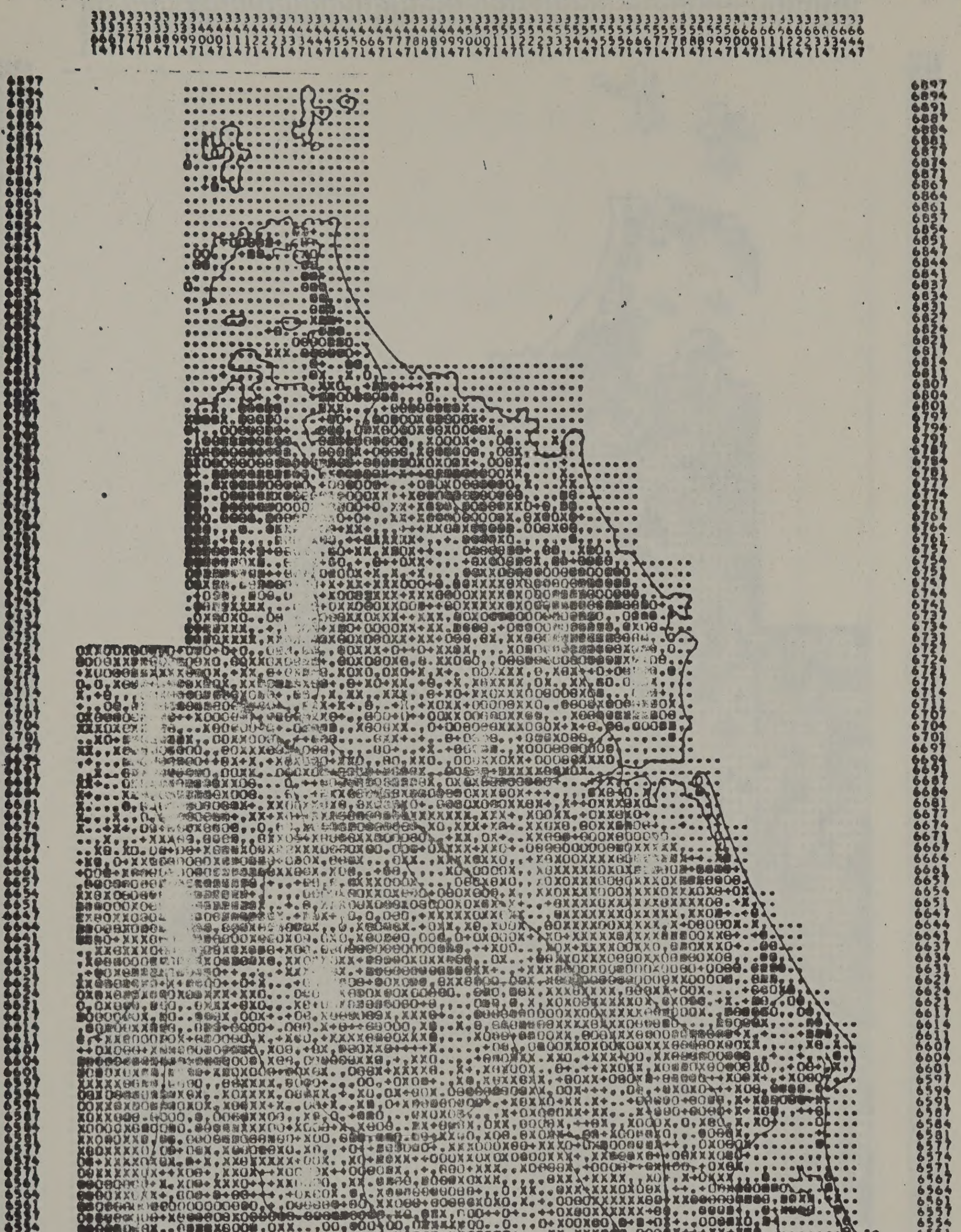


FIG. B.50 BOSTON REGION : SOUTHEAST SECTOR
POTENTIAL DAMAGE TO WATERSHED BY CHANGE

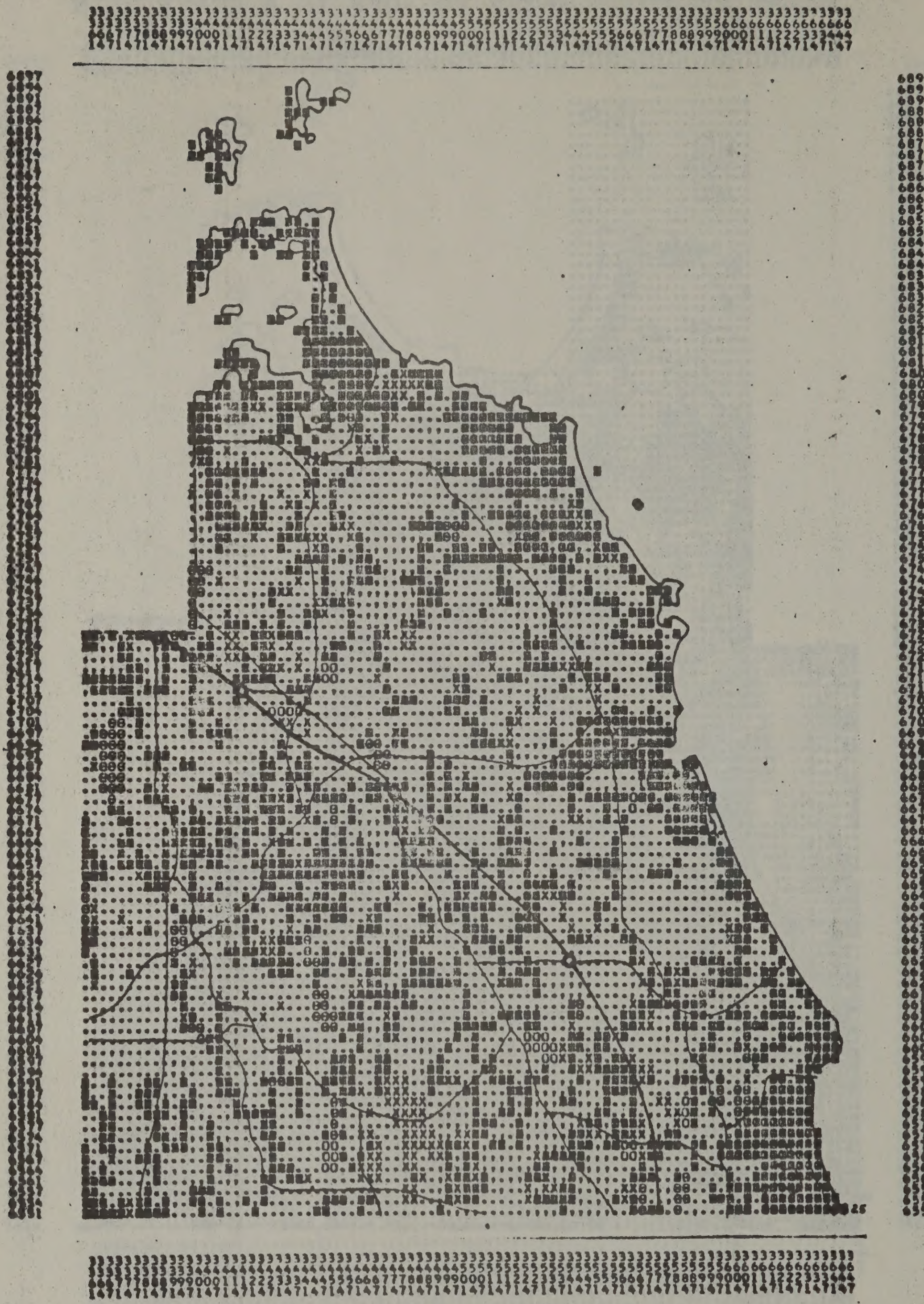


FIG. B.51 BOSTON REGION : SOUTHEAST SECTOR IMPACT OF OCEAN ON SHORELINE

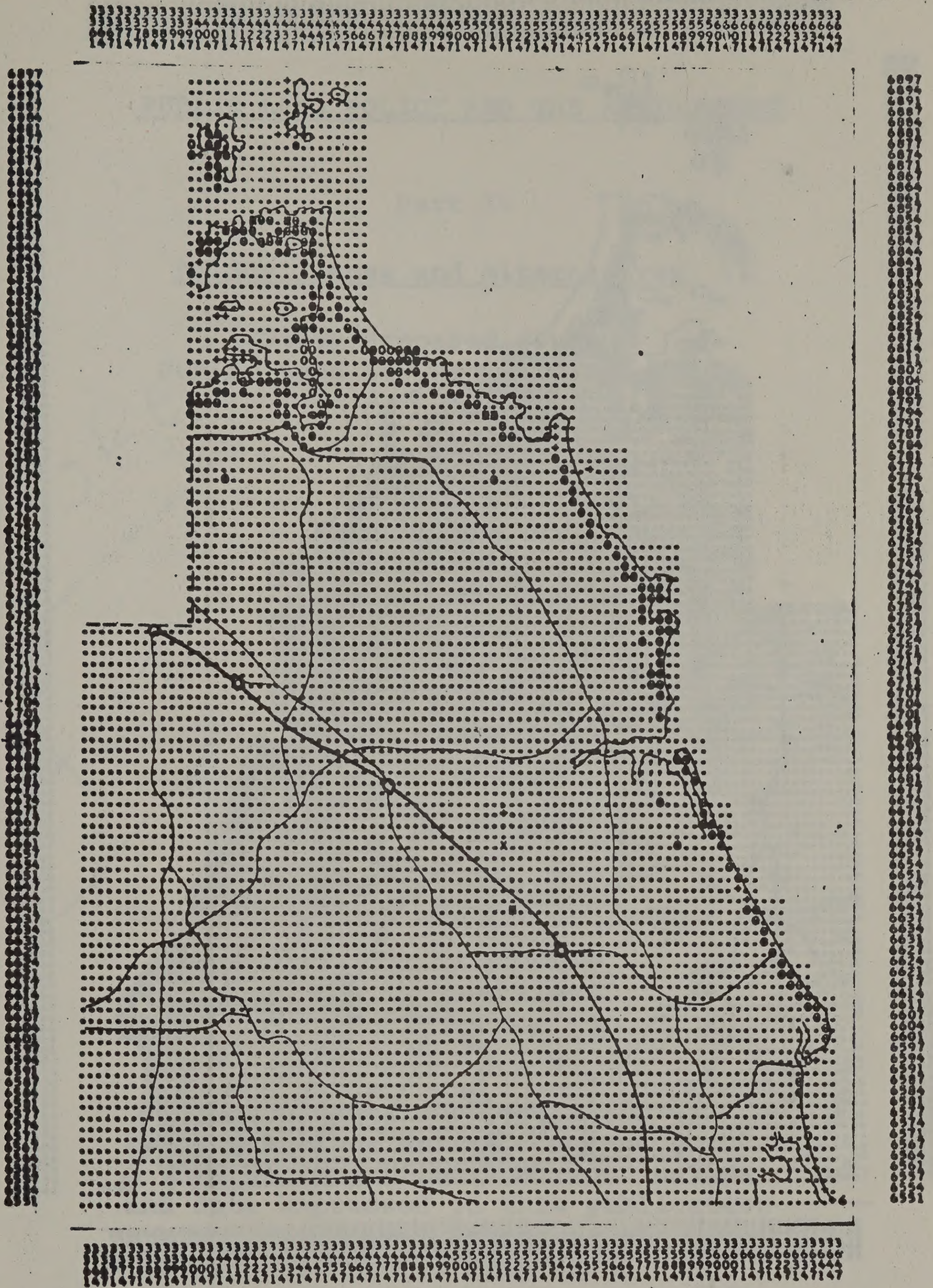
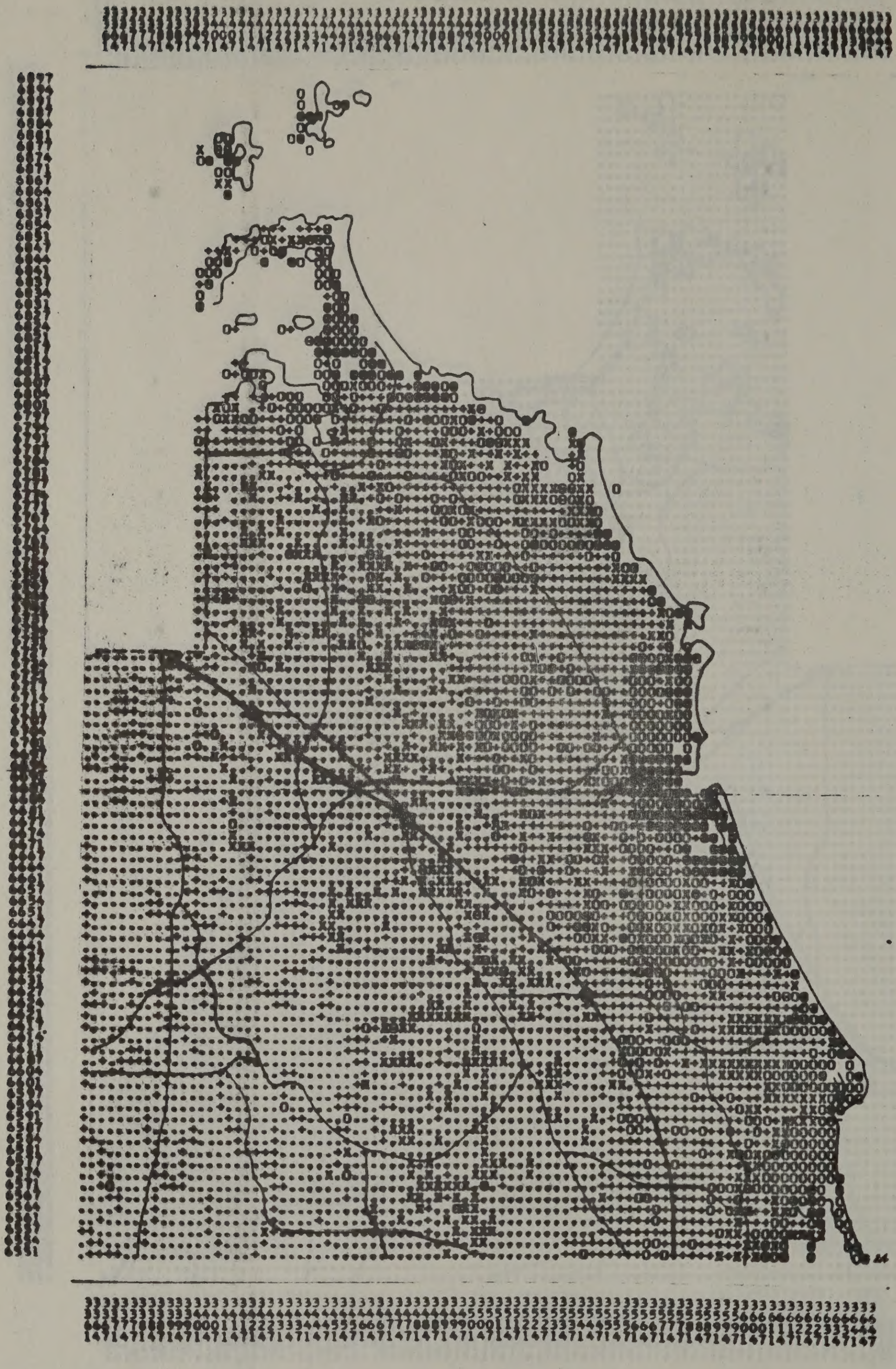


FIG. B.52 BOSTON REGION : SOUTHEAST SECTOR SUSCEPTIBILITY TO HURRICANE DAMAGE



GPO 887-671

PUBLIC LAND POLICY AND THE ENVIRONMENT

Part IV

Policy Issues and Alternatives

A Study Prepared for the
Public Land Law Review Commission

CORE PAPER

by

Roger P. Hansen
Ira Michael Heyman
Robert H. Twiss

(Republished with revisions December 1970)

Prepared under contract with the Public Land Law Review Commission.

The opinions, findings, conclusions and data expressed in this publication are not necessarily those of the Public Land Law Review Commission.

This publication constitutes only one of a number of sources of information utilized by the Commission in the conduct of its public land study program.

TABLE OF CONTENTS

A. Introduction 1

B. Policy Issues and Alternatives 5

- I. Criteria and Standards for Environmental Management. . 5
- II. Environmental Information and Analysis 9
- III. Planning and Management Practices. 13
- IV. Supervision and Enforcement by the Managing Agency . . 20
- V. Review by Other Agencies 24
- VI. Public Participation 28
- VII. Control of Activities on Non-Federal Lands 31
- VIII. Timber 36
- IX. Recreation 37
- X. Mining 39
- XI. Use and Occupancy 46
- XII. Grazing 50
- XIII. Water Resources 53

A. Introduction

The Public Lands are at the heart of our Nation's environmental fabric. Public Land management can play a pivotal role in the rational pursuit of environmental quality.

The Commission's series of studies on environmental quality and the public lands discuss the level of environmental management on the public lands, and describe and evaluate relevant issues of public policy. The report on the legal and administrative framework (Part I) classifies environmental impacts, sets criteria for environmental management, and evaluates mechanisms by which environment is (or might be) taken into account in plans and decisions. The case studies (Part II) describe and analyze specific instances exemplifying common ecological problems related to the public lands. They investigate the historical and administrative settings of particular agency decisions ranging from such widely publicized events as the Santa Barbara oil spill and the impact of concentrated recreation use in Yosemite Valley, to such less well-known, but equally significant, topics as the environmental effects of fire and insect control. While by no means inclusive, the 17 case examples indicate the complexity and breadth of environmental problems on public lands, and provide a substantive basis for the discussion of policy issues treated here. The studies of methodology (Part III) offer an independent view of new approaches and techniques in environmental study and planning. They help establish a baseline for evaluating procedures now in use by the public land management agencies.

This report (Part IV) seeks to serve two purposes:

First, by way of introduction, it briefly reviews the nature of environmental impacts peculiar to various types of land uses and site conditions as exemplified by the case studies.

Second, and of greater importance, this report presents major policy issues and alternatives formulated on the basis of the legal and administrative study (Part I) and the case analyses (Part II).

The Nature of Environmental Impacts of Public Land Use

Environmental concerns are significant in that they permeate virtually the entire structure of the land management agencies. Part I of this report documents to some extent the depth and complexity of environmental involvement in terms of agency policy, organization, procedures, personnel, and funding. Indeed, there is little in the way of agency activity that does not bear in one way or another upon environmental quality.

But environmental concerns [illegible]

physical and biological changes being wrought by public land use and management. The nature, extent, and seriousness of environmental problems has been described in Part II of the report, in the recitation of the seventeen case studies. While Parts I and II were neither comprehensive nor exhaustive in their coverage, they do help characterize the situation and provide illustrative material for a general evaluation of environmental problems.

Perhaps the most basic point illustrated by the case studies (Part II) was that environmental problems are extremely varied in their nature and composition. Some developments, such as dams on the Snake River (Case #13) or mines in the Shirley Basin (Case #4) might be acceptable as individual actions, but are cause for major concern when replicated over wide areas. Others, such as the Santa Barbara Oil Spill (Case #11) involve development of a fairly small percentage of total public land holdings, but take on significance through ecological chains of events.

Problems such as the Oil Spill are dramatic and of immediate consequence; others, such as fire prevention policies on forested lands (Case #8) take effect over a period of decades and involve environmental changes and hazards that are more subtle, if no less insidious.

Environmental degradation on public lands may affect mainly the direct users, as in the Yosemite Valley example (Case #15) or, on the contrary, may also incur costs to interests off site, or down stream, as in the Pass Creek logging example (Case #9).

All components of natural environmental quality have been threatened by one or more land uses. And no one type of land use can be designated the primary culprit. For example, soil stability is threatened not only by logging practices that are inappropriate to the landscape (Botholith Granitic, Case #1), but by recreational misuse, as exemplified by off-road vehicle use (Case #16).

Environmental effects may stem from resources management practices such as grazing (Case #6) or logging (Case #9), where the agency has full responsibility and capacity for control. Of increasing significance, however, are developments which are external or tangential to the agency's principal missions. The Wheeler Refuse study (Case #12) describes how highway construction can drastically affect a resource management program. The Lake Tahoe inquiry (Case #2) explores problems caused by rapid urbanization of an ecologically sensitive region. These examples raise questions as to agency responsibilities to provide leadership in programs of environmental quality management for the entire regions within which they operate, including non-Federally managed lands.

The following statement of Policy Issues and Alternatives is organized in relation to the chronological order in which issues logically occur in the decision making process. Thus, the issue of criteria for environmental management is considered first, followed by questions concerning information acquisition and analysis, planning practices, supervision, review, public participation, and control. In order to emphasize conclusions that relate mainly to a particular resource or agency, but which do not typify the general situation, additional issues and alternatives are organized under specific resource topics.

The "yardsticks" against which existing policies have been judged, and toward which alternatives have been developed, are discussed in some detail in the section on Criteria for Environmental Management in Part I, and in the Introduction to the case studies in Part II. Briefly, these "yardsticks" concern the clarity and specificity of goals, the extent of coordination and cooperation, the validity of information, the pace of the planning process, the extent and timing of public participation, the number of personnel and their qualifications, and the level and timing of funding. The introduction to each policy issue sets forth the general problems being addressed.

B. Policy Issues and Alternatives

I. Criteria and Standards for Environmental Management

The land management agencies have a plethora of objectives and directives to promote consideration of aesthetics, wildlife, and related values. But definitions, criteria, and standards for environmental quality are vague and lack operational meaning. Except in some instances where air and water standards are specified and made capable of monitoring and review, environmental goals are essentially "motherhood statements." Standards are often identified only at the lowest level, where a public reaction has focussed on obvious or flagrant disregard for environmental concerns. In this process, policies tend to respond to highly visible, or short term problems, rather than to a careful assessment of long term environmental effects.

Policy Issue #1:

There is a lack of clear criteria and potentially achievable operational standards for measurable elements of environmental quality. Only with regard to the most straight-forward physical elements of the environment has the Federal government taken sufficient action to develop criteria for environmental quality. Water and air pollution standards in this regard could be used as example for expanding a measurable set of quality objectives for other components of the environment. Without a broad spectrum of standards for different parts of the environment (open space, visual parameters, parks, and wildlife), it is often difficult for environmental quality considerations to hold a strong position in the decision-making process.

Alternative #1: A single governmental agency at the national policy level should establish a set of comprehensive standards relating to all facets of the environment. No single public land management agency has the range of responsibilities necessary to embrace this wide scope. The task, therefore, could best be handled by a non-management body such as the Council on Environmental Quality.

Advantages:

1. This would promote uniformity among different agencies at the operating level, and would greatly assist in setting management priorities in land practices. One set of standards would provide Congress and the Executive Office with a yardstick for assessing agencies' performance in environmental improvement.

Disadvantages:

1. If standards are set by an agency outside of front-line management

responsibility, unrealistic or unattainable standards might be imposed.

Alternative #2: Develop an environmental quality land classification system incorporating a range of standards, one for each aspect of the environment. This is a zoning process designed to permit various degrees of ecological integrity, each zone with a separate permissible level of disturbance in terms of vegetative change, soil compaction, and water quality. A rudimentary system of this kind was devised by ORRRC in its recreation classification system. The Forest Service zoning system could be adapted to this purpose.

Advantages:

1. Classification would force agencies to develop specific criteria for environmental quality, and would provide field level personnel with clear guidelines.

Disadvantages:

1. This type of zoning would have the same faults as present zoning regulations. There is no guarantee that it could be made operational, especially as it is difficult to map environmental zones because of the transitional nature of different environments. It would require vast amounts of data and inventory material, and might in the end achieve only a slight variation on land use plans now already functioning and in use by most Federal land managing agencies.

Alternative #3: New Federal legislation should be enacted, establishing environmental standards for all Federal public lands. Fair and equitable standards will require innovative Federal legislation. The initial steps in this direction have already been taken in the passage of the National Environmental Policy Act. This suggested alternative is a continuation and extension of the intent of that Act.

Advantages:

1. Environmental quality standards would rest upon a statutory base and have more directive effect than administrative policy.

Disadvantages:

1. It is difficult to develop one set of standards which could be enacted into law with equal applicability to all public land environments.

Policy Issue #2:

There is a serious lack of specific criteria and standards for the as yet non-measurable attributes of a quality environment. While it is recognized that subjective and value judgments play an important role in arriving at standards for the so-called "intangibles," this has not prevented us in the past from taking major positive action on such problems as education and public health.

Alternative #1: Establish a national jury or set of juries to develop and recommend standards for aesthetic and other non-quantifiable elements of our environment. A substantial amount of well-accepted professional judgment exists on matters of this type. Professionals in landscape architecture, psychology, art, education, architecture could assist agencies in developing environmental standards.

Advantages:

1. This alternative would make use of existing knowledge, and professional judgment that at present has been largely untapped with regard to public land use policy. It could provide a fund of information and talent beyond that which exists in the land managing agencies.

Disadvantages:

1. There is hardly enough current understanding of the subject to make it translatable into useful policy. Most individuals trained in the various areas appropriate to this policy issue have little or no training in the basic ecological and management principles upon which land management decisions must be based.

Alternative #2: Apply existing information, incomplete as it now is, at the operational level as best as can be done. Several agencies have developed rudimentary techniques for quantifying the values of hunting and fishing, and ways of recognizing and assigning values to areas of high scenic and ecological importance have been adopted.

Advantages:

1. There does exist a small pool of knowledge which should be put to work until better material is developed.

Disadvantages:

1. Existing information is slim at best in terms of the total need. Putting it to use now might only be a shift in the kind of mistakes made rather than an elimination of them.

Alternative #3: Build public involvement into the decision-making system as a technique for evaluating non-measurable attributes of the environment. The statement of different personal expressions might help clarify the range of values at stake in management decisions. A public hearing system could be used as a vehicle to obtain these different viewpoints. This alternative would act as a substitute for the knowledge that as yet has not been provided the agencies by the professional world.

Advantages:

1. The public, in any event, should be involved to some degree in decisions on public lands, and their involvement could bring better acceptance of decisions once made.

Disadvantages:

1. Such hearings are likely to produce such diverse opinions as to prove useless to the decision-makers. Often, hearings only widen the area of conflict rather than developing constructive courses of action. This would be an unmanageable process having the effect of producing delays in needed action programs and, at best, could give only spotty coverage to widespread problems.

Alternative #4: Agencies should be given financial support to place more qualified professionals on their staffs to assist in making qualitative judgments. More environmental design professionals could reduce frustration and unwitting mistakes at the policy and field levels of operation. Men trained in these areas should share decision-making authority with individuals trained in the more traditional areas of biology, natural resource management, and economics.

Advantages:

1. In-house experts could permit early consideration of non-measurable features of a quality environment. Their products could be built directly into the land management plans.

Disadvantages:

1. Trained men in these subjects are in short supply, and many lack the breadth of knowledge in ecology and resource management needed adequately to pass judgments.

II. Environmental Information and Analysis

Although single-purpose exploitation or preservation requires only minimal amounts of information, their alternative, environmental management, is strongly dependent on relevant and accurate data. The justification for environmental management rests heavily on the presumption that through study and scientific judgment, the ecosystem can be manipulated with foresight and control. Thus, information, and the mechanisms for insuring its availability, relevance, and validity are of primary concern. Generally speaking, however, information now used in environmental management varies from adequate to marginally useful, depending on the scale of decision, time, presonnel and funds allocated to study.

Policy Issue #1:

There is a lack of information on environmental characteristics at the regional level (i.e., state or multi-state region). Broad land-use policies and coordinating requirements are promulgated on the basis of assumptions, and "available" information which (although it may indeed be the best available) is commonly incomplete, only marginally relevant, or overly general.

Alternative #1: Compile environmental information for the public lands on a regional basis, and make such maps and documents available through designated regional libraries or centers.

Advantages:

1. This would provide a focal point for information access and agency coordination.
2. Existing research centers (such as Forest Service experiment stations) could be utilized at the outset.

Disadvantages:

1. Environmental problems are so complex that the diverse types of information would be difficult to manage, index, and retrieve.

Policy Issue #2:

Information at the planning unit level is incomplete and widely scattered through reports and memoranda. Since many development alternatives and policy conflicts are resolved at this level, environmental concerns tend to be put off or overlooked in the fast pace of day-to-day work and decision making.

Alternative #1: Collect and map environmental information at the planning unit level, as is done in the Bureau of Land Management Unit Resource Analysis.

Advantages:

1. Potentially available information is made actually available for reference.

Disadvantages:

1. Unless valid information is made available through detailed (and costly) surveys, the mapping process and resource analysis become academic exercises.

Policy Issue #3:

Information on specific sites is of variable quality, especially in regard to off-site impacts of developments.

Alternative #1: Require impact studies of site developments of a given magnitude (see the following Policy Issue).

Alternative #2: Require development proponents (or the proponent unit within the agency) to furnish detailed impact data as part of the development prospectus (see Alternative 1 & 2 of Policy Issue #4, in Section III.)

Policy Issue #4:

Impact Studies that are used to evaluate the effect of major projects (e.g., reservoirs, roads, timber sales) are often inadequate to the extent that they: are not conducted at all for some major projects (especially those that are in-service), are often done quickly with little or no original data, are based on superficial and overly general background data, reflect the sponsoring agency's bias, or fail to consider project rejection (as well as impact mitigation measures) as an alternative.

Alternative #1: Require uniform policies and procedures for impact studies, for example, directing that impact studies be conducted for all projects involving over $1,000,000 or land-use changes of over 40 acres of land; that a minimum of one year be provided for study, and that studies include an assessment of environmental ramifications and costs and benefits, both with and without the project.

Advantages:

1. The impact study would become a formal part of the planning

and decision process and a key means of identifying and evaluating environmental problems. This would help to avoid trial and error development.

2. Projects need not be delayed if studies are begun early in the planning and development process.

Disadvantages:

1. Personnel and funds would have to be made available to avoid project delays.

Policy Issue #5:

There are insufficient personnel and funds for environmental surveys and impact studies. Many separate agencies are inevitable depending upon (e.g., the Geologic Survey in the Interior Department, the Soil Conservation Service and Forest Service in Agriculture). Development of improved regional and planning unit data will further tax this present system.

Alternative #1: Create or designate an independent, quasi-government, research and development organization. This group would accomplish any or all of the following functions: compile background information for national or regional planning purposes, set standards for research and impact studies, conduct or sponsor environmental surveys, advise on or conduct Impact Studies, consult on environmental impact problems, supervise field tests of new technology or land development practices, provide independent review or assessments of agency studies, and perform project follow-up and monitoring.

Advantages:

1. This would provide a mechanism for expanding environmental work without increasing numbers of Federal personnel.

2. It would also provide a resource for third party review of controversial projects.

3. New directions in environmental surveys and research could be quickly undertaken, and a flexible program capable of rapid expansion and contraction could be created drawing on university and consultant talents.

Disadvantages:

1. There would be considerable overlap with existing agency programs, and competition for the same scientific and professional talent.

2. Continued funding might be difficult to achieve unless linked to funding for construction and management.

Alternative #2: Create an inter-agency program for environmental management studies. Certain research, survey, and staff functions in the Forest Service, Park Service, and BLM, and possibly Bureau of Sport Fisheries and Wildlife, U.S. Geologic Survey, and Soil Conservation Service, could be linked through memoranda of understanding. A joint committee could advise on direction and content of surveys and study projects.

Advantages:

1. Coordination and data sharing could be improved, as would joint utilization of remote sensing and other surveys.

2. Present single-factor surveys (soil, geology, vegetation, . . .) might be combined with economy.

Disadvantages:

1. The inter-agency committee is cumbersome.

2. Separate funding might perpetuate single-purpose research.

Alternative #3: Expand existing agency research and management staff personnel and financial resources.

Advantages:

1. Present programs offer a starting point; prudent increases could have immediate effect.

Disadvantages:

1. Present disjointed efforts would be perpetuated.

III. Planning and Management Practices

Research and survey information regarding environmental quality must be brought to bear on decision-making in order to be effective. Agency efficiency in this regard is uneven. One way it is brought to bear is through directives stating what is to be taken into account in making particular decisions and what weights are to be given to various considerations. Another is through the planning process where, in general, different activities are assigned different spatial areas. This also includes "action planning"--the specific locations over time of the various activities. The last also involves specific site design and management of the activity.

Policy Issue #1:

Agency directives concerning environmental quality are often very broad and simply sensitize administrative decision-makers to environmental considerations without giving directions as to what factors should be taken into account and what weight is to be given to them. The BLM's new manual provisions (BLM Manual 2031) seek to remedy this problem and are perhaps as specific as is possible. The recent objectives statements by the Chief of the Forest Service, on the other hand, are very vague, although statements of Regional Foresters are more precise.

Alternative #1: Every federal land management agency (or Regional Office thereof) should be required to formulate a set of directives which are as detailed as possible concerning the specifics of environmental quality. These should be given wide circulation and adequate opportunity should be allowed for the comments of interested persons and groups.

Advantages:

1. Generates self-conscious effort by agency experts to foresee and deal with environmental dangers.

2. Provides specific guidelines for decision-makers who are not experts in the anticipation and amelioration of environmental harms.

3. Raises environmental quality concerns to the same level as production concerns.

Disadvantages:

1. Requires a considerable effort that might not be justified

by pay-offs.

2. Might be technically difficult to treat in detail differing local situations.

Policy Issue #2:

Large regions within which federal land management agencies operate contain definable areas which exhibit particular environmental sensitivities. These include proneness to earthquake hazard, soil slippage, erosion, air pollution, fragility of a wildlife resource such as anadromous fish, and the like. Identification of these areas is a problem (see Policy Issue II-1 above). If relevant identifications are made, systematic means must be established for utilizing such information.

Alternative #1: Relevant areas should be mapped at the Regional (or State) level and particular management directions should be stated to guide the field offices in determining uses to be carried on within the areas and necessary ameliorative steps.

Advantages:

1. This is an efficient way to transmit the information in an authoritative manner. It fits in especially well in the Forest Service planning system.

2. This system is a good basis for determining when specialist teams should be dispatched to design a particular project, such as a timber sale or a road.

Disadvantages:

1. The system might stimulate over-reliance on generalized information and discourage the taking of adequate precautions in areas not mapped as sensitive.

Policy Issue #3:

Directives and planning activities that seek to uncover resource and use relationships prior to the design of a particular project are usually too general to identify particular environmental dangers. For instance, coordinating requirements and management directions and decisions in the Forest Service Regional Guides and District Multiple Use Plans often fail to pin-point specific areas of particular sensitivity or to set forth precise measures needed to avoid environmental damages in a particular location such as stream pollution from a road.

Alternative #1: Require intensive data gathering and analysis by local units (e.g., BLM planning units and sub-district areas within

Forest Service Ranger Districts) and the preparation of map overlays recording such information before significant projects are undertaken.

Advantages:

1. The ranking of such information would help assure sensitive consideration of environmental dangers whenever a resource or activity decision was to be made.

Disadvantages:

1. The compilation of such information would be very expensive and little of it would be used for any particular project.

2. This process would require expert personnel not now available at the local level.

Alternative #2: The agencies should require sophisticated impact studies at the action planning stage (before actual project design but after the general alternative locations for the projects have been determined) to be carried out by experts at the Regional or sub-Regional levels, especially in areas identified as potentially sensitive.

Advantages:

1. This system would be more economical than Alternative #1 in requiring intensive analysis only in relation to a projected undertaking.

2. This would permit the pooling of experts and thus reduce the need for personnel.

Disadvantages:

1. It would be difficult to give the experts a veto power and would require decisions to be made at higher levels if disagreement resulted between the land manager and the team.

2. Land managers might hesitate to call in staff from higher echelons.

Alternative #3: Impact studies as described in Alternative #2 should be completed and reviewed prior to the letting of any bids (e.g., for a timber sale) or the decision to fund or commence any agency project. Too often, impact studies are still being carried out as the project is being designed or commenced.

Advantages:

1. Such a rule would assure that the impact study had its major potential effect.

Disadvantages:

1. Such a rule might elongate the decision making process and cause unwanted delays.

Policy Issue #4:

Directives and planning documents cannot anticipate all problems or set forth with precision what values are to be given determinative weight in all instances. Land managers and their immediate superiors have to take ultimate responsibility for resource and activity decisions, but there is no widely-used process which assures that the managers will give sufficient attention to environmental issues in making individual decisions.

Alternative #1: Directives should stipulate the general environmental considerations that should be consciously weighed by the land manager with regard to each important resource or activity decision. The directives might incorporate the directions contained in the National Environmental Protection Act, viz.: consider for every important resource and activity decision:

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
(iii) alternatives to the proposed action,
(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Advantages:

1. Such directives would focus the land manager's attention on the environmental consequences of his acts, would require him to assess alternatives, would make him sensitive to his lack of authority, if any, and would put him on notice of the standards against which his performance will be measured.

Disadvantages:

1. It will be difficult to predetermine the line between important and unimportant decisions.

2. It will be difficult to police the system unless the manager's determinations are reduced to writing.

3. Managers will undoubtedly view such a directive as either superfluous or meaningless and will resist its implementation.

Alternative #2: Require the agencies to adopt a form specifying the considerations outlined in Alternative #1, which must be completed and signed by the manager before a project is undertaken.

Advantages:

1. Same as under Alternative #1, except the impact of the directive would be greater.

Disadvantages:

1. The statement calls for a sophisticated judgment based on considerable data, both of which might well be lacking, especially at the manager's level.

2. The process might inhibit any action where there is any chance of environmental harms occurring. This is especially true if the manager is to be held responsible for unanticipated harms.

3. The system might eventuate in many more decisions being deferred to higher levels than is presently the case.

Policy Issue #5:

Many management decisions consist of incorporating precise conditions and directions in contracts and permits which control the actions of private persons and corporations who make use of agency resources. Examples include timber sale contracts, grazing permits (many of which incorporate range management plans), mineral leases, and special use permits. Contract and permit provisos must be definite in order to be effective. Often, however, they are indefinite and do not spell out precisely the obligations of the permittee.

Alternative #1: Prepare standard form contract and permit provisos at central and regional offices, covering all anticipatable environmental hazards, which can be inserted by land managers in contracts and permits with as few modifications and specially written insertions as possible. Classify the provisos in a manner that lead to their easy discovery and use by the managers.

Advantages:

1. Instrument drafting is difficult, and expert resource and legal talent can be assembled at higher levels.

2. Well-drawn provisos provide a usable reference list for managers as well as a control device.

3. The drafting of model provisos requires agency personnel to think through environmental problems in an operative context.

4. The chances that a permittee will follow prescribed conditions is heightened if he has specifically agreed to them.

Disadvantages:

1. Certain provisos might tend to become dated.

2. The effort can be expensive.

Alternative #2: Incorporate by reference in contracts and permits the regulations and other directives of the agency.

Advantages:

1. This is an easier and more expeditious format for the contracting officer.

Disadvantages:

1. Particular problems are not brought to the attention of the land manager or permittee.

2. The chances of effective enforcement are probably less than if a specific and noticed agreement were reached.

Policy Issue #6:

Various planning and management practices designed to assure environmental quality and to repair environmental harms that have occurred and will occur in the future impose significant costs. Existing budgets are inadequate to support intensive data collection, necessary expert personnel, and the carrying out of particular ameliorative projects.

Alternative #1: Maintain land management agency budgets at present levels but allocate, in addition, all or a portion of receipts from such activities as timber sales, grazing permits, and special use permits to be used for environmental-related activities.

Advantages:

1. The system will produce significant amounts of earmarked funds.

2. The funds will be generated from users whose activities threaten environmental impacts.

Disadvantages:

1. This system might stimulate greater effort to develop and capitalize on saleable commodities and thus might tend to be "self-defeating."

2. It will be hard in the long run to maintain operating budgets that do not take into account the earmarking of the receipts.

3. The process will not generate additional Federal revenue--it will simply allocate, somewhat indirectly, a larger share to the land management agencies.

IV. Supervision and Enforcement by the Managing Agency

All land management agencies have internal procedures for monitoring and supervising their own land managers and for enforcing conditions placed on permits and licenses. These are crucial activities. Directives, plans and management directions regarding environmental quality might be exemplary; without adequate supervision and enforcement, however, they might be nullities.

Policy Issue #1:

Agencies supervise some permit operations closely, to the extent of available personnel, and others sporadically. Minimal on-site presence of federal officials undoubtedly leads often to failure to obey relevant conditions and regulations. A problem is funding necessary personnel to monitor and inspect, for instance, grazing practices, operations on mineral lease sites, logging, power line installation and the like.

Alternative #1: Assign more agency personnel to monitoring and supervision.

Advantages:

1. Permits more detailed review and anticipation and control of harmful activities.

Disadvantages:

1. Costly and personnel not available in sufficient number.

Alternative #2: Require by statute or regulation that permittees pay fees necessary to support supervisorial personnel.

Advantages:

1. Extra-agency source of support.
2. This is a conventional means for supplying funds necessary for an effective inspection system. For instance, it is utilized in most cities to fund building code inspection services.

Disadvantages:

1. Adds to the cost of permitted activities.

Policy Issue #2:

If a permitte negligently or wilfully undertakes harmful activities or disobeys conditions designed to protect environmental quality, difficu is often encountered in collecting damages to pay for the correction of the harm.

Alternative #1: Statute, regulation or directives should embody standards guiding the discretion of land managers (and agency and U.S. attorneys) in determining whether or not to bring civil suits to recover damages. The standards should require suits to be brought in most instan

Advantages:

1. This procedure should generate more law suits and deter harmful negligent or wilful conduct.

2. Standards would allow managers to "shift" the responsibility for the hostile decision to press suit to higher levels and thus make it easier to bring more actions.

Disadvantages:

1. It is difficult to codify standards of prosecutorial discretion.

2. Law suits are a costly process for assuring indemnification.

Alternative #2. Statutes, regulations or directives should require the posting of performance bonds by permittees (modelled on the Forest Service timber sale contract proviso).

Advantages:

1. Collection should be easier and thus the deterrent effects more pronounced.

Disadvantages:

1. Effective use of bonding requires precise criteria that are difficult to draft.

2. Bonds are expensive for the permittee.

Policy Issue #3:

Fines(preferably civil) can be an effective control mechanism if they are large enough to "hurt" and if there is an effective process for their imposition and collection. It is reported, however, that fine schedules for certain transgressions (e.g., overgrazing) are so low that they are easily absorbed as a reasonable cost of doing business.

Alternative #1: Authorize and require agencies to adopt schedules of fines that will be imposed for specific transgressions. The fines sho be realistic in amount so as to deter harmful conduct, but not so large as to be difficult to impose. The amounts, however, should bear some reasonable relation to the cost of remedying the harms created by the transgressions. Fines should generally be imposed by land managers subject to administrative, and limited judicial, review.

Advantages:

1. "Automatic" fines give clear notice to permittees and are relatively easy to administer.

2. Fine schedules can be reviewed by interested groups, including users, and the process can provide a means for public consideratio of environmental impacts associated with particular activities and the balancing of output with harms.

Disadvantages:

1. Sole reliance on a schedule of fines to deter harmful activities will fail if the fines are so low as to be absorbed easily as a cost of doing business.

2. Considerable time and effort is required to pre-state the conditions under which fines will be levied.

Policy Issue #4:

In many instances, adequate supervision requires constant monitor of the environmental impacts of an activity that has been undertaken und a permit. For instance, recreatinn activities carried on at hotels, restaurants, skiing facilities, and the like, might produce pollutants which affect the quality of a stream or lake and which could not adequat ly be foreseen. To guard against these impacts constant or periodic monitoring processes must be used. These can range from inspections to automatic counting devices. Often such processes are not used and harmful environmental conditions do not come to agency attention until they have progressed to dangerous or highly distasteful levels. Earlier discovery, moreover, would often permit cheaper amelioration.

Alternative #1: Require permittees to carry on monitoring activities for designated environmental impacts and submit regular reports to agency supervisors.

Advantages:

1. Setting up monitoring systems focusses the attentions of both the permittee and the agency on particular environmental risks associated with the activity.

2. This system passes on much of the cost of monitoring to the permittee where it can be passed on to users and consumers of his "products."

Disadvantage:

1. Adds to the cost of the permitted activities.
2. Requires some supervision by agency personnel.

Policy Issue #5:

Inspection of the performance of land managers by supervisory personnel is the primary control system to assure the adequacy of environmental management practices. To be effective for this purpose, however, the inspectors must take environmental consequences of activities seriously and must be thoroughly acquainted with theenvironmental impacts that are to be noted.

Advantages:

1. This is an additional means to transmit agency attitudes towards the importance of environmental management.
2. The process would not be costly.

Disadvantages:

1. It would be difficult, initially, to fashion reporting forms that identified environmental management criteria with precision.

Policy Issue #6:

In order to build up usable experience concerning successful and unsuccessful environmental management practices, regular means for reporting and reviewing the adequacy of particular programs must be developed and utilized. This requires building an evaluation component into various management programs, a practice often lacking in line agencies. Evaluation, in turn, requires a statement of a measurable goal before the program begins and analyses during and after the program to determine to what extent the goal has been realized.

Alternative #1: Annual work programs should require the statement of a measurable environmental goal for selected undertakings (e.g., water quality in a particular stream of "X" consistency), the setting up of "experimental conditions" so that a particular system to attain the goal can be tested, and a means for reporting the results for agency-wide use.

Advantages:

1. This provides an on-going means for developing and testing verifiable programs to improve environmental quality.

2. Forethought at the national, regional, and sub-regional levels would permit simultaneous testing of alternative means for addressing various environmental problems at various field locations.

Disadvantages:

1. Cost.

2. Land managers would often need expert help to set up and monitor testing programs.

V. Review By Other Agencies

Review and monitoring mechanisms relating to environmental quality vary among the agencies. There is no established procedure for systematic review of plans, programs and decisions by other than the managing agencies themselves. "Outside" review occurs, but only in special circumstances, normally upon the occurrence of an ecological disaster. Arguably, more effective review could be provided by agencies other than the managing agencies. Such review could be directed: (a) to the general adequacy of agency procedures and programs for assuring environmental quality; and (b) to particular projects or proposals that are the subject of complaint or controversy.

Policy Issue #1:

It would be arguably desirable to establish some mechanism for extra-agency monitoring, review and evaluation of the general adequacy of agency procedures and programs for assuring environmental quality, and the environmental impacts of agency activities and decisions.

Alternative #1: Establish by statute or executive order an interagency panel or panels (a) to review and assess the adequacy of agency programs to satisfy stated environmental goals and objectives; (b) to prepare annual reports reviewing the agencies' performances for the Council on Environmental Quality (CEQ); (c) to review and update goals and standards of environmental quality; and (d) to recommend legislation necessary to enable the managing agencies effectively to protect environmental quality. The review panel should have a multi-disciplinary staff and be authorized to utilize outside expertise as needed. It should report both to the land management agencies and to the CEQ. Its findings and recommendations should normally be matters of public record.

Advantages:

1. An effective checklist would undoubtedly evolve to determine if adequate environmental quality control measures were being formulated and implemented by the agencies.

2. The existence of the panels would stimulate the development of a "technology of environmental quality" by bringing together information from all land management agencies.

3. Ultimate review of decisions by "outside" panels could stimulate higher standards of agency performance.

Disadvantages:

1. Centralized review might tend to over-standardize control measures and stifle agency initiative to find new methods.

2. Another layer of review could slow down the decision-making process unduly.

3. Inter-agency panels might not be sufficiently independent.

Alternative #2: The responsibilities outlined in Alternative #1 could be assigned by statute to the Council on Environmental Quality whic would have to be provided with an enlarged staff and would probably have to establish regional offices.

Advantages:

1. The CEQ now exists and this mission would complement its existing statutory missions.

Disadvantages:

1. It is problematic whether an agency working out of the Executive Office of the President could undertake such a detailed reviewing function without considerable decentralization of responsibilities which might prove infeasible.

Alternative #3: The Council on Environmental Quality might be auth ized and directed to establish and staff Regional Commissions composed of knowledgeable representatives of various groups interested in environmenta quality matters to exercise the responsibilities outlined in Alternative #1. These either could be advisory to the Council or exercise reviewing power independently.

Advantages:

1. The "local" nature of such Commissions would permit more detailed review of agency operations within the region and would allow peculiarly "local" values to be expressed in weighing outputs against harms.

Disadvantages:

1. "Local" agencies might take an overly parochial view of environmental questions harmful to the national interest.

2. The mechanism would be costly.

Alternative #4: An independent federal agency might be created (similar to the Commission on Civil Rights or the Public Land Law Review Commission) to exercise the responsibilities outlined in Alternative #1. Such an agency would have full investigatory powers and ample staff. It might be provided authority to create state or regional advisory committee

Advantages:

1. Relative independence from both the Executive and Legislative branches would provide the agency with extensive freedom to report both favorably and unfavorably to the President, the Congress, and the public.

Disadvantages:

1. The costs would be considerable.

2. The agency might find it difficult to gain practical entry into agency operations unless it had a very knowledgeable and ingenious staff.

Policy Issue #2:

It would be arguably desirable to establish an independent administrative mechanism to review particular projects and proposals of land management agencies upon complaint or upon the motion of the reviewing agency, and to vest in the agency the power to veto or modify such project or proposals in order to protect identified environmental values.

Alternative #1: Establish by statute an independent quasi-judicial Public Land Review Board with jurisdiction to entertain petitions from affected parties and citizens organizations to review particular undertakings of land management agencies and to delay, veto or modify proposed actions in accordance with environmental quality standards set forth in statute, in regulations issued by the Council on Environmental Quality, or in regulations issued by it. This agency could be the same independent agency referred to in alternative #4 above and thus could exercise both legislative and quasi-judicial powers similar to such agencies as the National Labor Relations Board. It could also be empowered to review a proposal on its own motion and to consider matters involving the public lands other than those respecting environmental quality.

Advantages:

1. The costs of operations would be high, but considerably less would be spent than is required for judicial litigation.
2. Such an agency would be considerably more expert than courts.
3. The availability of full administrative review would deter management agencies from taking unwise environmental risks.
4. Would enable the systematic evolution of regulations and administrative case law.

Disadvantages:

1. Could result in considerable delays in implementing important land use decisions.
2. It is hard to predict how effectively one federal agency could review the activities of another.
3. Could cause considerably more litigation.
4. Might cause management agencies and citizens' groups to become adversaries earlier in controversies and thus discourage informal dialogue and compromise.

Alternative #2: The Council on Environmental Quality could be charged with the responsibilities set forth in Alternative #1.

Advantages & Disadvantages:

1. Largely the same as outlined above.

Alternative #3: Establish by statute a Public Lands Court (simila to the Tax Court) with appellate jurisdiction from the decisions of the independent reviewing or with original jurisdiction to review contested actions of the management agencies. Appeal from this court would be to either a Court of Appeals or the United States Supreme Court.

Advantages:

1. Would provide a reviewing court with judges highly competent to deal with both technical and policy issues regarding the public lands.

Disadvantages:

1. Would undoubtedly encourage litigation and thus further delay additional land use decisions.

VI Public Participation

Public participation in agency decision-making processes is quite uneven. There are different rules and practices from agency to agency and within agencies with respect to different functional and planning programs. Public participation through formal public hearings is generally disliked by agency managers. Hearings, however, and other devices for participation, can serve several salutary environmental purposes. New information is brought to agency attention. Preferences are communicated. Inadequate analyses are pin-pointed. The pressure of public opinion is focussed on a particular decision which might otherwise have been made relatively clandestinely.

Policy Issue #1:

Formal public hearings should be required before decisions are made that involve substantial environmental risks.

Alternative #1: Require agencies to set up categories of decisions that must be preceded by public hearings at an early enough time so that the testimony presented can be used in the making of the decision. The categories should be ennunciated in a rule-making process in which citizen groups can participate. Adequate opportunity to affect decisions will require, in many instances, double hearings similar to those now required for certain federally-aided highways, the preliminary release of enough information to permit meaningful discussion of the major issues, adequate notice, a detailed presentation by the managing agency of the potential costs and benefits of the proposed undertaking, and a written public report following the hearings justifying the decision with respect to arguments made at the hearings.

Advantages:

1. The specification of classes of decisions requiring hearings will require the agencies (in concert with private groups) to assess potential environmental impacts of their activities

2. Well-publicized hearings under the conditions stated provide an important means for public influence on agency decisions.

3. The specter of hearings and public report will stimulate the agencies to do better impact surveys on proposed majors undertakings.

4. Careful hearing procedures will minimize the chances for successful litigation testing the agency's ultimate determinations.

Disadvantages:

1. Delay and cost.

Policy Issue #2:

Mechanisms in addition to formal public hearings are needed to inform the public of environmental problems, to seek public viewpoints, and to permit public inquiry.

Alternative #1: Advisory boards should be constituted that are primarily concerned with environmental issues. These could be similar to various industry and Forest and Regional advisory boards utilized by the Forest Service. Alternatively, existing advisory boards might be enlarged to include a substantial number of "environmentalists." The agencies should involve these boards in reviewing major proposals involving risks of environmental degradation and agency practices generally regarding environmental quality.

Advantages:

1. A means for getting expert advice.

2. Allows discussion and persuasion in a non-adversary setting.

3. A potential means for involving representatives of major conservation groups.

Disadvantages:

1. Members might be restricted to persons who are not broadly representative so that the existence of the board would falsely give the impression of searching public participation.

Alternative #2: Establish an office of "ombudsman" at Departmental levels with representatives located in local areas who make inquiries, review citizen complaints (including those related to environmental issues) and try to resolve controversies. The Ombudsman's chief power would be disclosure and/or report to the Secretary. They would have ample powers to make investigations and rended advisory opinions.

Advantages:

1. Such independent investigators could clear up many misunderstandings before they erupted into major public controversies or costly lawsuits.

2. Ombudsmen could establish continued dialogue between citizens and agencies on a non-adversary basis.

3. Ombudsmen could help educate citizens in public lands matters and, conversely, make agencies more aware of legitimate citizen interest and concern.

Disadvantages:

1. It is questionable whether these persons could fulfill the usual ombudsman's role unless employed by an entirely separate institution such as an independent agency of the Congress. (Regardless of the title, though, the threat of direct disclosure to the Secretarial level would often be a powerful weapon.)

2. It would be difficult and costly to recruit expert personnel who have the personal attributes necessary for such a job.

VII. Application of Federal Standards to the Agencies and the Activities On and Off the Federal Lands

It has been urged that the federal agencies take the lead in stimulating high environmental quality standards. This might be accomplishe with respect to activities occurring on the federal lands, activities off the federal lands, and activities in the regions where there are appreciable concentrations of federal land.

Policy Issue #1:

The Federal Acts and the Executive Orders concerning both air and water quality do not require that federal agencies meet federal and state pollution standards although the agencies are urged to do so "insofar as practicable and consistent with the interests of the United States and within any available appropriations."* Moreover, the Military Construction Authorization Act of 1969 has been interpreted to bar the construction of water pollution control facilities on military installations until local communities in the vicinity have constructed such facilities.

Alternative #1: While many land management agencies by directive require adherence to federal and state standards, federal statute should require all agencies to do so unless particular state standards are discriminatorily applied to the federal activities.

Advantages:

1. There is no understandable reason for the federal government in its regulatory capacity to impose higher standards of pollution control on state, local and private activities than it is willing to impose on its own proprietary activities

Disadvantages:

1. None noted.

Alternative #2: Statutes and Executive Orders should direct federa agencies to take the lead in constructing facilities to minimize air and water pollution rather than inhibit such activity until adequate state and local facilities have first been constructed.

---

* The Water Quality Improvement Act of 1970 was adopted after this Policy Issue was drafted. Section 103 of the Act provides that federal agencie must comply with general water quality standards, consistent with the paramount interest of the United States. In addition, Executive Order 11507 issued on February 4, 1970 (also after this section was drafted) requires federal agencies to conform to air quality standards as established under the Clean Air Act, as amended, 42 USC 1857, et. seq.

** The Military Construction Authorization Act of 1970 does not contain thi limitation.

Advantages: (as above)

Alternative #3: High exemplary environmental standards, especially for air and water quality, should be developed for application on the federal lands. These would constitute maximum standards to complement the minimum standards now imposed by the federal government in its regulatory capacity.

Advantages:

1. This process would help to develop new technologies and standards that would be adopted voluntarily by many states.

2. The federal government, through such a process, would indicate the seriousness of its environmental undertaking.

Disadvantages:

1. Cost.

2. The higher performance demanded on the federal lands might be wasted if activities in the lands adjacent areas produced considerable pollution.

Policy Issue #2:

Often activities carried on within in-holdings and on adjacent lands pose serious environmental threats to the federal lands. This is true, for instance, on roads leading to National Parks, watershed, rivers, in-holdings that are subdivided for vacation homes or are developed for mineral exploitation, and the like. By and large the federal agencies exercise minimal authority to regulate activities occurring on these places. In large part this is due to the lack of statutory authority although it seems likely that such statutory authority could constitutionally be granted.

Alternative #1: Statutes should be adopted granting authority to the federal land management agencies to impose land use regulations on in-holdings and adjacent areas designed to protect the federal resources. The statutes should be carefully drafted to outline the purposes and the limitations of such authorizations respecting different contexts.

Advantages:

1. Such authorizations would give the agencies requisite power to protect their resources from serious environmental harms over which they presently have no control.

2. Such authorizations would protect national resources from harms now permitted to occur because of parochial self-interests and lack of expertise or resources in rural local governments which normally administer in-holdings and adjacent lands.

Disadvantages:

1. Police power regulations would be adopted by a government far removed from those whose lands would thus be regulated.

Alternative #2: The efforts towards greater cooperation between the agencies and local governments regarding zoning and planning as explored in the Study of Regional and Local Land Use Planning done for the PLLRC should be stimulated and subsidized.

Advantages:

1. This process permits greater participation by land-owners in the fashioning of regulations.

2. It might be a better vehicle for assuring that local objectiv are not ignored.

Disadvantages:

1. This is a time-consuming process that depends on the development of local expertise in rural governments which are under financed and normally ill-disposed towards land planning and regulation.

Policy Issue #3:

The federal agencies generally lack the authority and the direction to impose particular environmental conditions on the off-site activities related to their products.* These include particular resources such as timber (e.g., controlling air pollution connected with the burning of wastes generated in milling and other processing). This also involves land disposed by, for instance, the BLM (e.g., including in the patent disposing of federal land covenants regarding uses and activities).

Alternative #1: Direct the Council on Environmental Quality, an independent federal review agency (as indicated in part V above), or the Department of Interior to review and analyze (for report to the President and Congress) the environmental impacts resulting from the use of commodities produced on the public lands and to draft performance standards which could be applied to product users. The studies and recommendations should concentrate on determining types and degrees of environmental impacts from the use of federal land commodities off federal lands. Examples of commodity uses and impacts include mining smelters using minerals from public lands and causing air or water pollution; paper mills depending on wood products from federal forests and causing air and water pollution and degradation of landscape esthetics; feed lots situated near federal grazing lands causing water pollution and offensive odors; "T-pee burners" from sawmills which depend on federal lands for sawlog supply; and others. Certain environmental quality controls would be a condition of commodity use.

---

* Section 103 of the Water Quality Improvement Act of 1970 (adopted after this section was drafted) provides that applicants for federal licenses and permits who may discharge into navigable waters must comply with general water quality standards. There is no like statutory provision regarding air quality. Existing law does not clearly provide that the federal agencies can use their contract, loan and grant processes to control potential private polluters who are not licensees or permittees.

Advantages:

1. Performance standards would provide incentives for voluntary programs by commodity users wanting to obtain public land products.

2. Such standards would substitute in part for absent or ineffective local planning, zoning, sanitation and other environmental controls.

Disadvantages:

1. Such a process would undoubtedly generate considerable political conflict.

2. Performance standards would be very difficult to create except with respect to a few commodities.

3. Such standards would invite considerable litigation (like any new regulation).

4. This process would increase the costs of public lands commodities.

Alternative #2: Authorize and direct the BLM to condition various federal land exchanges and disposals on agreements, covenants, contracts or other appropriate legal devices to maintain particularized standards of environmental quality. These might take the form of precluding certain uses or imposing measurable performance standards. Remedies could include reversions and damages and injunction suits. Imposition of conditions would normally relate to the protection of resources on retained federal lands.

Advantages:

1. It would be an effective means for controlling environmental pollution occuring on lands formerly owned by the public and which affects the public lands.

2. It would help to fill the "gap" created by absent or ineffective local or state controls over land use.

Disadvantages:

1. It would create difficult and costly inspection and enforcement problems.

VIII. Timber

The location and timing of timber sales in old growth areas are matters of broad environmental concern. Land uses are altered, country is "opened up" to road-oriented recreation, and roads and timber harvest operations bring about substantial environmental alterations.

Policy Issue #1:

Considerable time and effort has been invested by the Forest Service and the BLM in designing management practices to assure sustained high yields of timber and to insure land use coordination. Much less effort, however, has gone into assessing the environmental impacts of production-oriented directives such as the determination of the allowable cut.

Alternative #1: Direct that a through study be made of the environmental impacts of timber policies, including the formulas for calculating allowable cut, timber sale and contract provisions, the planning process, the financing of timber access roads, and the effects of new programs for intensive timber management. The study could be carried out under the auspices of the Council on Environmental Quality, with assistance from the Forest Service and the BLM.

Advantages:

1. The above policies, though already much studied and debated, could be scrutinized from an environmental point of view, with sufficient study time and resources to make detailed and reasonable recommendations.

Disadvantages:

1. Further study might only clarify the value positions underlying the problem and constructive solutions would be created only by a substantial and innovative study effort.

IX. Recreation

Several unique issues arise from the rapidly expanding recreational use of public lands, and its concomitant impact on environmental quality.

Policy Issue #1:

The ambiguity of agency missions (to provide a sustained quality of recreation resources while at the same time providing for their use and enjoyment) contributed to the problem of resource deterioration.

Alternative #1: Clarify agency missions (notably that of the National Park Service) to direct that recreation use may be provided only in so far as resource quality is not impaired.

Advantages:

1. This would establish environmental priority.

Disadvantages:

1. "Resource quality" is not subject to precise definition, and there is danger in seeking a uniform standard. Some areas should be set aside for intensive recreation use, even though this will entail some resource deterioration, in order to protect higher priority areas.

Alternative #2: Agencies might be directed to establish a formal classification of recreation lands, and for each class, set clear design standards, and use quotas.

Advantages:

1. Elements of this system already exist (BOR classifications system, and the Forest Service campground standards), and rationing of use, by type and location, is likely to be done at some point in time, given increasing use and limited resources.

Disadvantages:

1. Administration and supervision tasks would be made more difficult. Each agency may tend to resist setting quotas and reducing its visitor "head count", unless inter-agency directives require uniform procedures.

Policy Issue #2:

Large numbers of recreation visitors, spread over vast areas of public land pose special problems in management, administration, and control. Specifically, the Bureau of Land Management lacks authority to control visitor problems such as vandalism and unauthorized use.

Alternative #1: Give BLM land management personnel the same powers that Park Service and Forest Service personnel now possess.

Advantages:

1. This gives minimum needed control on a uniform basis.

Disadvantages:

1. Authority alone will be insufficient without also improving mechanisms for handling cases and providing additional supervisory personnel.

X Mining

Mining activities on the federal lands pose particularly acute environmental problems.

Policy Issue #1:

The Federal agencies do not now have adequate statutory authority to control mining operations under the Mining Laws of 1872 so as to limit or prevent adverse environmental impact. Mineral locators are free to enter any public lands not withdrawn from mineral location, regardless of the environmental values such lands may have; to conduct exploratory and discovery operations which may scar the landscape; to conduct mining operations without regulation by the land management authorities; and, in most cases to dispose of tailings without rehabilitation. Federal law should provide for essential protection of environmental values affected by mining operations under location, as well as leasing, laws.

Alternative #1: The Bureau of Land Management presently has temporary authority to segregate its lands from mineral location by publishing a notice of proposed classification of the lands as suitable for either disposal or retention in federal ownership for multiple use management. The Bureau of Land Management should be granted permanent authority to segregate lands classified for disposal from the mineral location and mineral leasing laws. The land management agencies should be authorized to withdraw areas which are environmentally sensitive or valuable from mineral location. This authority should be placed on a permanent basis. The land management agencies through development and use of new or existing planning systems should identify these lands whose enviromental values would be damaged or destroyed by mineral location or development and should withdraw those areas from such location or development. Temporary withdrawals of such areas should be permitted for reasonable time periods until adequate environmental impact studies have been conducted.

Advantages:

1. Lands with environmental values which could not otherwise be protected from the effects of mining operations would be protected by classification and withdrawal before any damage was done.

2. In examining the lands currently open to mineral location, the land management agencies might develop fuller information about the environmental, mineral and other values present, and might develop valuable experience in classifying lands deserving special protection because of environmental values.

Disadvantages:

1. Withdrawal authority in the agencies, without extensive review and appeal protections, might be abused.

2. Withdrawals might be made on a hasty basis, as the agencies were faced with impending mineral development; withdrawals, even if initially appropriate, might be difficult to overturn later.

Alternative #2: The Mining Laws of 1872 should be amended to require developers to apply to the land management agency for the right to explore or mine on the public lands and to accept conditions required to protect environmental values. The law could require that mineral claimants apply for access permits and preliminary exploration permits, appropriately conditioned to protect environmental values. Mineral development itself might be similarly condition, either in the context of a leasing or patenting system. The administering agency should be explicitly granted the authority to control the location and construction of access roads to mining operations.

Advantages:

1. Mineral developers would not be free to act without consideration for environmental values, but would be held to standards requiring them to conduct their operations consistent with such values.

2. Surface disturbances, including road building as well as exploration and development work, would be limited by standards designed to protect the landscape.

3. The land management agencies would have continuing authority to regulate mining operations and to revoke the mining privilege if it were abused.

4. The public interest in the resources on the public lands, other than minerals, would be protected, consistent with mineral development.

Disadvantages:

1. Such a system of regulation might be seen as inconsistent with the expanding mineral needs of the nation. Arguably, the incentives which lead miners to prospect in the hope of significant discoveries would be diminished.

2. Imposing conditions upon operations in order to protect environmental values likely would lead to additional expense for the miner.

3. A regulatory system which empowered the land management agencies to attach conditions to mining operations to protect broadly-conceived environmental values might be seen as subject to abuse unless carefully limited by legislative standard

Alternative #3: The Mining Laws of 1872 should be amended to permit discovery work by means which do not require, or which minimize, disruption of the landscape. Surface cuts may not provide much evidence of the nature and extent of mineralization, but they do scar the landscape. If modern technology will permit the identification of probable mineralization without needless disruption of the surface, technology should be recognized as adequate for a discovery.

Advantages:

1. Federal legislation on this point could prevent needless cuts of the surface when mineralization is not present and this could be ascertained by other methods.
2. Federal legislation could bring a uniformity to discovery requirements in different states.
3. A uniform standard, based upon modern technical knowledge, should eliminate cuts which are made for technical compliance with the law only and not as a means of exploration.

Disadvantages:

1. If surface cuts were not required for discovery, notice of claims would have to be given by another means. While a uniform system of filing might give adequate notice to other claimants, it could entail additional expenditures of time and money.
2. Some small operators may not be able to afford technological devices which permit discovery of minerals without excavation.

Alternative #4: The land management agencies should be authorized to manage the ways in which tailings are disposed of or rehabilitated. Since the impact of tailings upon the environment is direct and substantial, this may be an appropriate area into which to extend federal management authority.

Advantages:

1. Regulated disposal and rehabilitation of tailings could mitigate an obvious environmental impact.
2. The existence of a uniform federal standard might encourage companies to develop uniform policies for their operations throughout the country.
3. The existence of such a national policy coupled with federal funds for research, might give mining companies an additional

incentive to pursue rehabilitation programs already instituted by them.

4. Effective regulation of tailings, disposal and rehabilitation might alleviate associated problems such as air pollution, water pollution, and soil erosion.

5. Such a program would require mining companies to assess more accurately the total costs of their operations by requiring them to mitigate disruptions caused by them.

Disadvantages:

1. This program would be quite expensive and discourage mining companies from undertaking operations except those which clearly are economical even with the new costs of rehabilitation. This would not be in the public interest if our national policy were to encourage the development of mineral resources.

2. Such a program might be unfair if applied to tailings from past operations. Mining companies arguably should not now be expected to pay to reclaim what previously was accepted as a social cost.

3. Voluntary programs are most consistent with the traditional mining on the public lands, and such efforts may be expected to produce acceptable results as rehabilitation technology develops.

4. Regulation of the disposal and rehabilitation of tailings may be merely a "cosmetic" effort and detract from efforts on which emphasis more properly might be placed, such as the development of mining techniques which involve the disturbance of less of the landscape.

Policy Issue #2:

Potential oil shale development presents special problems of waste disposal. If the shale is mined by traditional underground methods, there will be vast amounts of spent shale to be disposed of. Filling valleys with the spent shale could produce a variety of environmental problems, including the drastic alteration of drainage patterns and the possiblity of water pollution. Mining techniques which may not require the disposal of such vast amounts of material, such as in situ retorting, are in the formative stages and bear their own potential environmental problems. Before there is full scale development of oil shale on the public lands, the waste disposal and other environmental problems should be faced squarely.

Advantages:

1. This program would draw upon the technology being developed by private companies.

2. If the companies had an opportunity to explore development, mining, and retorting techniques while placing primary emphasis on environmental protection, the program might offer a special economic incentive to the companies participating.

3. Such a program could provide the basis for comprehensive regulations if commercial development of the federal oil shale lands occurs.

Disadvantages:

1. The program might involve excessively detailed federal regulations. A preferable approach might be to set broad standards for environmental protection and to rely upon the ingenuity of the oil companies to provide such protection, consistent with the various mining and retorting processes which they may employ.

2. It can be argued that federal research efforts and expenditures would be better directed toward finding a substitute for fossil fuels, rather than toward further development of fuels which have produced demonstrably serious environmental impacts.

Alternative #2: As an alternative to efforts to develop regulations for extensive surface disposal of mined materials, consideration should be given to developing in situ=technology. Although the in situ process may be promising for oil shale devlopment and for environmental protection, it offers its own set of environmental problems which will have to be identified and analyzed.

Policy Issue #3:

Offshore leasing of oil and gas presents special problems. The full extent of possible environmental impacts is not yet known, although they are known to be serious. The possibility of substantial revenue for the Federal Treasury and the expenditure of substantial sums by oil companies place both the government and the companies under pressures to develop the resources. Better methods of ascertaining the environmental hazards with respect to potential lease areas should be developed. More effective supervision of leased areas should be instituted.

Alternative #1: Meaningful public participation should be required before the decision to lease is made. If public hearings are to be meaningful, adequate notice must be give, highly technical information made availa and understandable to the public, and the basis for the decision, together with the findings of the hearing body, published. Applicant companies might be required to submit certain "proprietary" information developed by them with appropriate safeguards.

Advantages:

1. Public participation is the most effective way to insure that all available knowledge will be brought to light and assessed before a leasing decision is made.

2. Because the public has an overriding interest in the quality of the environment a full discussion of the issues should be required. Public participation should be required in all decisions that relate to resource uses having potentially serious environmental effects.

3. The existence of a public hearing procedure might lead the government and the oil companies to develop more comprehensive information than is presently available, and to present carefully considered, detailed plans for development.

4. The use of public hearings might lessen the tax and financial pressures on the government to grant off-shore drilling leases. The agency would not grant a lease unless important environmental values could be protected.

Disadvantages:

1. A public hearing procedure could be extremely unwieldy. It could take an unworkable amount of time, effectively delaying needed resource development.

2. Because the issues involved are so technical and complex, most segments of the public could not be expected to come effectively to grips with them. The result might be a mass of largely irrelevant testimony which might obscure the real issues for decision.

Alternative #2: Either as an alternative to, or a supplement for, Alternative No. 1, the responsibilities for federal investigation and decision-making might be placed in an independent agency. The responsibility for examining critically the potential environmental impacts of leasing should rest with an agency whose mission either is solely to ascertain all facts or to act in the role of an environmental protection agency. In any event, responsibility for making the leasing decisions should be insulated from any agency mission which would predispose the decision.

Advantages:

1. Giving investigation responsibility to an independent agency should lead to a more complete development of facts. The companies might be willing to work cooperatively with such an agency, sharing information developed by them and presenting the facts justifying leasing in a less emotionally-charged atmosphere than a public hearing.

2. The agency might require the testing of new technologies before they were employed in the environmentally sensitive areas.

3. If the agency had the responsibility of protecting environmental values and if there were a public hearing, the agency could act as an effective proponent of the public interest in environmental quality. It would have the information and expertise which the general public would not.

Disadvantages:

1. This agency could become a captive of a particular point of view. Precautions would have to be taken to avoid undue influence upon it. If it were constituted as an environmental watchdog, its role in the final decison-making process, where competitive values were weighed, would have to be carefully defined.

2. The agencies which now make pre-leasing investigations arguably are those best qualified to do so, since by training and mandate they have the responsibility for weighing competing values to serve the public interest.

3. The companies perhaps should not be required to divulge "proprietary" information developed by them, especially if such information developed by them would enter the public domain through the report of an investigating agency or in a public hearing.

Alternative #3: A moratorium might be imposed on all offshore leasing until a comprehensive study upon the possible environmental impacts can be completed. Such a study profitably might be combined with a massive federal program to investigate the possibilities of non-fossil fuels.

XI. Use and Occupancy

Policy Issue #1

The Classification and Multiple Use Act of 1964 (hereafter CMUA) only provided temporary authority for the BLM to classify its lands for retention in Federal ownership and to administer them under a program of multi use management. Although the Taylor Grazing Act can be interpreted as providing permanent statutory authority for such multiple use management, the lack of an explicit statement as to the permanent authority of the Bureau to manage its resources under such a program causes uncertainty as to its future management policies and practices. A permanent statutory directive authorizing classification of lands for multiple use management is needed.

Alternative #1: Permanent authority should be given to the Bureau to conduct a continuing classification program designed to identify publi land resource values. This classification authority should define the objectives of public land management in such a manner as to permit the Bureau to respond effectively to future user pressures on public land resources. Permanent authority should also be given to the Bureau to manage its lands under a multiple use program in order that the maximum possible economic benefits are derived from the public lands consistent with a policy of preserving and protecting the public lands resources. The definitions of management objectives should be broad in order to be responsive to future resource needs. The Bureau will have to be able to respond to these future pressures in such a manner as to identify and prohibit undesirable practices.

Advantages:

1. By granting the Bureau permanent authority to classify its lands and to manage its lands under a multiple use program, the Bureau will be better able to develop procedures that will identify and protect the public lands' resource values.

2. By granting the Bureau such permanent authority, the Bureau will be able to administer its management program on the basis of a more accurate calculation of future benefits and needs and will therefore be better able to evaluate the short-term effects of proposed management actions.

Disadvantages:

1. The grant of permanent management authority will require additional staff and money to administer effectively the classification and planning systems necessary to implement the objectives of the management program.

Policy Issue #2:

The Bureau of Land Management administers its lands and resources under a variety of statutory and administrative authorities. Some of the land disposal laws have become outmoded; others provide for results inconsistent with effective land management practices; and still others require administrative actions which are inefficient and wasteful. Public land management agencies should be able to protect adequately public lands resources values by having the power to direct properly the disposition of the public lands. To accomplish that objective, it would be desirable to consolidate all disposal authorities into one comprehensive statute, applicable to all Federal land management agencies.

Alternative #1: All existing disposal authorities should be repealed and a new, comprehensive disposal statute enacted. This new statute would be applicable to all Federal land management agencies: it should contain comprehensive criteria which would recognize the legitimate rights of the public and other governmental agencies to enter and to select public doma lands, but which would at the same time enable the disposal agency to condition such disposal upon an evaluation of the potential benefits and harms resulting from such disposal. Furthermore, such a statute should authorize the administering agency to segregate lands with particularly important public values from all forms of disposal. In addition, such a comprehensive statute would permit the disposal agency to deny such disposals unless adequate local zoning and comprehensive plans were in effect to insure that the disposal would be consistent with and beneficial to local, regional or state policies and programs.

Advantages:

1. A comprehensive disposal statute should enable the Federal land management agencies to limit filings for public lands and thereby eliminate the waste of time and money that currently results from responding to multiple petition applications.

2. Enactment of such a statute would be consistent with the polici of the statutes providing for multiple use management on Federal lands and would beneficially aid the attempts to create a management system that could identify and preserve public land resourc that have environmental quality values. Enactment of such a statute would provide the agencies with enough flexibility to resp to changing circumstances.

3. Such a statute would help rationalize many of the classification decisions by permitting the managing agency to identify those parcels of land that could materially aid either the management programs of other governmental agencies or private users.

4. Such a statute would tend to promote more consistent management decisions among the various Federal land management agencies.

5. By eliminating acreage restrictions, the managing agency could evaluate the proposed application as a self-contained unit and not wonder whether future applications would be made on adjoining property which was part of the natural unit.

Alternative #2: A uniform policy should be adopted governing permitted uses on federal lands. Although the actual evaluation of the proposed use would depend on the conditions peculiar to the affected lands, consistent policy guidelines would help establish general criteria. Use of such general criteria would also stimulate consideration of implications not otherwise included because of lack of time and money. Standa izing use considerations would also promote consistency of results and would help to eliminate situations where applicants dealing with more tha one agency could be subject to inconsistent conditional requirements and results.

Policy Issue #3:

There are a variety of statutes permitting private parties and othe governmental agencies to acquire rights-of-way across Federal lands in order to build roads and highways. For the most part, approval of these applications or requests can be conditioned upon proper protection of resource values, including environmental quality values. The major excep seems to be the lack of control over roads leading into mining claims fil under the General Mining Laws of 1872. It is also unclear what powers the Secretary of the Interior has over grants of rights-of-way under R.S. 2477 43 USC 932) for construction of highways over public lands not reserved for public uses. However, the issue of developing uniform crite to evaluate proposed rights-of-way and highways across public lands resolves itself into the question of whether such uniform criteria would of more protection to public resource values than the present separate crite administered independently by the managing agencies.

Alternative #1: This alternative would centralize the responsibilit for evaluating proposed roads and highways, for coordinating planning an construction standards for such roads. This power could be exercised fo all roads constructed on public lands or limited to those roads built wi federal funds or aid. Such a centralized operation could be located in either the Department of Transportation or in the Department of Interior.

Advantages:

1. Such centralized power could help to achieve uniform location and design criteria.

2. It would help to coordinate proposed road construction policie among the various administrative agencies and between the stat or localities and the administrative agencies.

Disadvantages:

1. It would be very difficult for such a centralized operation to be responsive to individual factual situations which required some variation from the uniform standards.

2. It would presuppose an extensive expertise which would in fact be difficult to assemble.

3. It would possibly delay decisions approving or disapproving locations and would otherwise be administratively unwieldy.

4. Although it might minimally assist in controlling the impacts of such an operation, coupled with the available alternative of passing a new law giving the existing agencies more control over the problem areas referred to earlier would be more desirable.

Alternative #2: Give unambiguous authority to the Secretary of Interior to control the location and construction of roads leading into mining claims and rights of way under(R.S. 2477 43 USC 932).

Advantages:

1. Such authority is necessary to protect a host of environmental objectives.

Disadvantages:

1. None noted.

XII. Grazing

Policy Issue #1:

When a portion of the public lands is used exclusively for grazing, other potentially useful activities are precluded; potentially more serious is the threat to environmental quality generally if an area's management concentrates on a single-purpose type of development. In the past, production-oriented administrative policy permitted a grazing allotment to carry as many AUM's as possible. This policy was qualified only by the vague condition that "serious degradation of the forage" was to be avoided. The result of this type of management was increased pressure on range environment. The numbers of nutritious, palatable plants was diminished, while the less nutritious plants increased. Total vegetation cover generally decreased, and this in turn led to secondary and tertiary effects such as increased erosion, soil depletion, sedimentation of waterways, water pollution, and generally, the decline in the vitality of the ecosystem to the detriment of both the stockman and other prospective users.

Alternative #1: Grazing should be rotated from one area to another on a predetermined schedule established with a view to maintaining the ecosystem at an optimum level of production, while protecting the environment. A stockman would have three or four areas open to him, to be used rotationally in different years.

Advantages:

1. During the years when a given area was not being grazed, forage plants would have an opportunity to reseed and store reserves.
2. Ecologically, the period of non-grazing would be very significant in permitting the re-establishment of plants detrimentally affected by grazing pressure.
3. Natural reseeding and plant establishment without disturbance would allow the maintenance of greater diversity within the ecosystem, thus protecting its stability.
4. In some areas water recharge of the soil and ground water table might be foreseen, to the great benefit of the environment.
5. Pressure on wildlife because of competition with livestock for forage would be relieved.

6. Opportunities for recreational use could be permitted.
7. The total carrying capacity of the area might be expected to increase because the period of recovery might favorably affect productivity.

Disadvantages:

1. Initially, AUM's of allotments would be reduced.
2. It could lead to overgrazing in the areas in which grazing was allowed in a given year.

Alternative #2: The optimum carrying capacity of each allotment under existing climatic conditions and with no treatment must be determined. (This determination must be reassessed periodically, preferably with the help of outside experts). Knowing what mixture of grazing animals, trees, shrubs, wildlife and soil conditions will produce a dynamic and healthy equilibrium will provide guidelines for range management of a sort to achieve optimum productivity without significant impairment of the environment.

Advantages:

1. The result should be the most productive and nutritive range possible, within such natural constraints as climate and soil.
2. The over-all value of the area, in terms of its component resources (wildlife, recreation, scenery, watershed, etc.) would be increased.

Disadvantages:

1. The number of AUM's per allotment would probably be decreased, thus, at least initially, the income from an allotment would fall.

Alternative #3: Intensive management pasturing might be attempted: this would entail fertilizing, weeding, irrigating, and seeding the land with highly nutritious grasses. The over-all management objective would be to produce the maximum forage yield for the site.

Advantages:

1. Forage would increase. Its level would remain more consistent from year to year.
2. More forage would increase the AUM's of an area, resulting in greater livestock productivity per acre.

Disadvantages:

1. This type of management would be much more expensive to the agency and the stockman.

2. It would tend to yield the preference to livestock over wildlife.

3. The introduction of alien species and processes might have deleterious effects on the treated land or adjacent areas.

Alternative #4: Within local management units, land should be classified or zoned according to its principal purpose. The object is to avoid conflicting uses, while preserving and developing the multiple use concept. Instead of attempting all or many uses on each piece of land, it is preferable to concentrate on one use in one portion with the entire area having many uses.

Advantages:

1. This approach to management should improve the quality of the environment for the recreationist.

2. It would promote the regeneration of forest areas which could be effectively protected from destruction through trampling and grazing of livestock.

3. Areas of high scientific value could be set aside, so that ecological processes could be observed unaltered by the presence of livestock.

4. Greater total diversity will increase stability, thus enhance total capacity to absorb change in a resilient manner.

Disadvantages:

1. The total area available for grazing would be reduced.

2. This system would require greater initial investigation and planning, and, once instituted, would perhaps be more difficu to administer.

XIII. Water Resource Development

A host of environmental impacts are produced by water resource developments. Generally speaking, contemporary decision-making processes tend to downgrade the importance of these impacts.

Policy Issue #1:

Project agencies with authority to license or recommend water projects which may affect water quality and other environmental values do not have explicit statutory mandates to protect the environmental values. Nor do the land management agencies within whose territory the projects are located. As the Middle Snake River case demonstrates, the Federal Power Commission has authority to consider the public interest in determining whether to issue a license, but has been reluctant to extend its consideration to all environmental values which may be affected by a proposed project. The Atomic Energy Commission's* apparent lack of authority to consider thermal pollution and other environmental effects from power projects which it may license provides another example. The Bureau of Reclamation is directed to investigate the feasibility of proposed projects, but the direction does not extend specifically to evaluating the environmental aspects of such a project. In order to protect environmental values in the decisions whether to authorize a water project and, if so, how and where the project should be constructed, additional legislation would be helpful.

Alternative #1: The Federal Power Act might be amended to direct the Commission more adequately to weigh and protect environmental values in its consideration of whether to issue project licenses. The authority might be implemented by staffing and funding the Commission to make thorough environmental studies or by strengthening the coordination provisions of the relevent statutes to require an independent agency or agencies to submit such an environmental report. Also, the possibilities of the Commission's protecting environmental values might be improved if the hearing procedures were modified as suggested in other portions of this study.

Advantages:

1. A specific directive to the Federal Power Commission to weigh and protect environmental values might lead it to take a more active role, rather than acting merely as an umpire for competing interests before it.

2. Such a statutory directive would broaden the Commission's mission and lead to consideration of a range of environmental values as well as power needs.

---

*A recent Executive Order apparently provides the Atomic Energy Commissio with the authority to control such thermal pollution.

3. Such a statutory directive might lead to a reassessment generally of our national power needs and the alternatives available for meeting such needs consistent with environmental and other values.

Disadvantages:

1. The Federal Power Commission may not be constituted to make decisions involving such a breadth of factors. It might be preferable to establish certain standards which must be met as a prerequisite to application for a power license and direct the Commission only to ascertain whether such specific standards can be met. Alternatively, this threshold inquiry might be made by another agency with more environmental expertise.

2. The proceedings before the Federal Power Commission may already be overly long and expensive. Arguably, procedures should be adopted which would expedite consideration of power projects, rather than extending the process further.

Alternative #2: Some agency should assess the environmental effects of water projects licensed by the Atomic Energy Commission. Congress currently is considering where authority for such an assessment should be lodged. The advantages and disadvantages of the different possibilities need not be repeated here. However, the need for some mechanism to make this assessment seems to be recognized.

Alternative #3: In addition to the present feasibility studies made on possible reclamation projects before their consideration by Congress, consideration might be given to specific studies directed to their environmental impacts. Such studies appropriately might be conducted by an agency other than the Bureau of Reclamation. These studies should provide Congress with a basis for determining whether the environmental impact is so great as to outweigh other resource values or whether environmental values may be protected by appropriate restrictions upon project construction.

Advantages:

1. A separate environmental study would give Congress, as the decision-making body, fuller information by which to evaluate a project.

2. The historic mission of the Bureau of Reclamation probably means that it is not the agency best qualified to prepare an environmental report. If such a report were prepared

by an independent agency and presented to Congress along with the feasibility report, the decision would be less likely to be cast in purely economic terms. Environmental values might be considered in their own right. A full evaluation of the values involved would be made at the highest government levels.

Disadvantages:

1. Current procedures, in which groups interested in environmental values may appear before Congressional committees, may provide a thorough airing of all values.

2. In a time of tight budgets and diminished emphasis on the needs of the people for water projects, perhaps the role of the Bureau of Reclamation should not be downgraded. It serves an essential function in representing the legitimate interest of a portion of the public. If an environmental evaluation is to be made, arguably it should be done by the Bureau of Reclamation as the agency with the relevant expertise.

Policy Issue #2:

Water development projects undertaken on federal public lands by federal "project" agencies, or with their authority (Bureau of Reclamation, Corp of Engineers, Federal Power Commission) are justified primarily on the basis of economic costs (planning, engineering, construction, some land acquisition, etc.) compared to economic benefits (irrigation, flood control, public or private power development, etc.). Recreation and fish and wildlife "enhancement" has recently been included in some project benefits; conversely, such enhancement costs are considered in many projects to be "non-reimbursable" to the project. Traditional cost-benefit analysis fails adequately to consider the total cost of certain project-caused environmental degradation (e.g., flooding a scenic valley or canyon, erecting transmission lines, bringing industry that causes water pollution, damaging natural fishery, inundating waterfowl habitat, flooding out big game range, causing thermal pollution, etc.) and to assign such degradation as an over-all project cost.

Alternative #1: Require water resources project development agencies using public lands and waters to undertake cost-benefit analyses which include all cost and all benefits, particularly environmental and recreation costs and benefits. This would call for the application of new "social accounting" techniques by all of the project agencies. The costs and benefits of not developing the project would also have to be considered as one alternative. Such an analysis could not be achieved without close coordination with all federal land management and natural resource agencies and without full participation by the public in the cost-benefit analysis process. Environmental resource inventories would be mandatory, as would the application of new techniques being developed to evaluate esthetic resources.

Advantages:

1. Many water development projects now considered "economically feasible" would fail in the planning stage after such an analysis, with resulting savings of both economic and environmental resources.

2. Water development project agencies would be required to give equal weight to environmental and recreational resources in all study, planning and design in order to make their project pass the feasibility test.

3. Hundreds of miles of natural stream, numerous scenic canyons and valleys, innumerable historic and archeologic sites, and acres of wildlife habitat would be "saved".

Disadvantages:

1. There have not yet been developed cost analysis techniques for many environmentally important values.

Alternative #2: Require that all environmental and recreation costs be assigned to water development projects, and that all costs of minimization, mitigation or enhancement of environmental and fish, wildlife and recreation values be "reimbursable" to the projects from project benefits. Even though some of the environmental and recreation "costs" are not yet quantifiable in traditional economic terms, federal land management agencies will have to be assigned to develop new techniques for quantifying or otherwise evaluating such values. Basic research on this problem should be undertaken by CEQ, Bureau of Outdoor Recreation and other appropriate agencies.

Advantages:

1. Such a process would require that water development projects "pay out" in terms of all costs, including environmental quality, recreation, fish and wildlife.

2. The process would make project agencies seek the best alternatives with respect to total cost.

Disadvantages:

1. Would tend to dismiss esthetic, cultural and spiritual values not subject to any program of quantifications.

2. Might tend to inflate the "economic" aspects of fish, wildlife and recreation, either as a cost or a benefit.

3. Could kill "worthy" projects that would be unable to reimburse environmental costs from project benefits.

OTHER PUBLIC LAND LAW REVIEW COMMISSION
STUDY REPORTS AVAILABLE

From the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402

Digest of Public Land Laws. Prepared by Shepard's Citations, Inc., of Colorado Springs, Colorado. 1968. $6.50

History of Public Land Law Development. Written by Professors Paul Wallace Gates of Cornell University and Robert W. Swenson of the University of Utah. 1968. $8.25

* * * * * * * *

From the Clearinghouse for Federal Scientific and Technical Information, United States Department of Commerce, Springfield, Virginia 22151

Clearinghouse prices for these reports are based upon the number of volumes into which each report is divided, indicated for each report in the following listing. Price: $3.00 per volume for paper printouts unless specified otherwise. $0.65 per volume for microfiche.

Federal Legislative Jurisdiction. Prepared by the Land and Natural Resources Division, United States Department of Justice. Revised September 1969. One volume. Order number P B 185 920.

Study of Withdrawals and Reservations of Public Domain Lands. Prepared by Charles F. Wheatley, Jr. Revised September, 1969. Order numbers: P B 187 002, P B 187 003, P B 187 004.

Administrative Procedures and the Public Lands. Prepared by The University of Virginia, School of Law. Revised September, 1969. One volume. Order number: P B 187 205.

Fish and Wildlife Resources on the Public Lands. Prepared by the Department of Fishery and Wildlife Biology, Colorado State University. Revised September, 1969. Two volumes. Order number: P B 187 246, P B 187 247.

Public Land Timber Policy. By George Banshaf & Company, Milwaukee, Wisconsin. Published in four volumes, Nos. PB 187 728, PB 187 729, PB 187 730, PB 187 731,

Federal Public Land Laws and Policies Relating to Intensive Agriculture. Resources portion by South Dakota State University. Legal portion by Kronick, Moskovitz, Tiedemann & Girard, Sacramento, California. Published in four volumes. Legal portion, Volume I, No. PB 188 061; resources portion, Volumes II, III, and IV, Nos. PB 188 062, PB 188 063, PB 188 064.

Development, Managment and Use of Water Resources on the Public Lands. By Charles F. Wheatley, Jr. Washington, D.C., Charles E. Corker of the University of Washington, Thomas M. Stetson, San Francisco, California, and Daniel J. Reed, Los Angeles, California. Published in two volumes, Nos. PB 188 065, PB 188 066.

Outer Continental Shelf Lands of the United States. By Nossaman, Waters, Scott, Krueger and Riordan, Los Angeles, California. Published in six volumes, Nos. PB 188 714, PB 188 715, PB 188 716, PB 188 717, PB 188 718, PB 188 719.

The Forage Resource. By The University of Idaho, Moscow, Idaho. Published in four volumes, Nos. PB 189 249, PB 189 250 , PB 189 251, PB 189 252.

Regional and Local Land Use Planning. By Herman D. Ruth & Associates, Berkeley, California. Published in four volumes, Nos. PB 189 410, PB 189 411, PB 189 412, PB 189 413.

Study of the Impact of Public Lands on Selected Regional Economies. By Consulting Services Corporation, Seattle, Washington. Revised November 15, 1969. Published in one volume, No. PB 190 164.

Land Grants to States. By Commission Staff. Published in one volume, No. PB 191 879.

State Land Resources and Policies. By Commission Staff. Published in one volume, No. PB 192 452.

Appraisal Techniques and Procedures Utilized in Connection with Actions Related to Federal Public Lands, by Kronick, Moskovitz, Tiedemann & Girard, Sacramento, California. Published in one volume, No. PB 193 529.

Inventory Information on Public Lands. By Commission Staff. Published in two volumes, Nos. PB 194 197, PB 194 198.

Disposal Techniques and Procedures. By Raleigh Barlowe, Department of Resource Development, Michigan State University. Published in one volume, No. PB 193 652.

Outdoor Recreation Use of the Public Lands. By Herman D. Ruth + Associates, Berkeley, California. Published in two volumes, Nos. PB 194 194, PB 194 195. $10.00 per vol.

Adjustment of Use Rights and Privileges. By the Commission staff. Published in one volume, No. PB 194 423.

Multiple Use Concepts and Land Use Decisions on the Public Lands. By consultants to the Commission. Published in one volume, No. PB 194 419.

Land Acquisitions and Exchanges. By Charles F. Wheatley, Jr. Published in one volume, No. PB 194 448. $10.00.

Future Demands on the Public Lands. By Commission Staff and five contractors and consultants. Published in four volumes, Nos. PB 195 041, 195 042, 195 043, 195 044.

Federal Land Laws and Policies in Alaska. By the University of Wisconsin School of Natural Resources. Published in five volumes, Nos. 195 294 ($6), 195 295 ($6), 195 296 ($6), 195 297, 1955 298 ($6).

Revenue Sharing and Payments in Lieu of Taxes on the Public Lands. By EBS Management Consultants Inc. Published in four volumes, Nos. PB 195 185, 195 186, 195 187 ($10), 195 188 ($10).

Federal Public Land Laws and Policies Relating to Use and Occupancy. By Daniel, Mann, Johnson & Mendenhall. Published in four volumes, Nos. 195 657 ($6), 195 658, 195 659, 195 660.

Organization, Administration and Budgeting Policy. By Commission staff with consultants. Published in two volumes, Nos. PB 195 661, 195 662 ($6).

Trespass and Unauthorized Use of the Public Lands of the United States. By Ireland, Stapleton, Pryor & Holmes. Published in one volume, No. PB 195 663 ($6).

User Fees and Charges for Public Lands and Resources. By Commission staff. One volume, now in press.

Criteria for Public Land Decisions. By Perry R. Hagenstein. One volume, now in press.

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225